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HEMIN AND CHLOROPHYLL— THE TWO MOST IMPORTANT PIGMENTS FOR LIFE ON EARTH[1]

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Two chemical processes are the prerequisites for all life on earth: the absorption of some of the energy from the sun in the green plants and its transformation into carbon compounds on one hand, and the use of the chemical energy of these compounds by animals in controlled decomposition reactions on the other.

From the chemist's point of view the green leaf is a veritable chemical laboratory: carbon dioxide from the air, and water and inorganic salts from the soil are the raw material, the visible portion of the sun radiation furnishes the energy, and the numerous complex constituents of the plant represent the manufactured products. Some of the substances synthesized are structural matter, like cellulose in the wood, or cork in the bark, others are food reserves, as starch in the grains of corn or wheat, or in potatoes. Of the many other materials produced in the green plant only a few may be enumerated here, sugars, fats, oils and waxes, proteins and nucleic acids, fibers like cotton or hemp, vitamins, hormones, indigo and other dyes, latex for producing rubber, alkaloids like the nicotin in tobacco leaves, valuable medicinally used compounds, such as quinine, cocaine, and morphine, and—most important—the green pigment chlorophyll. "Photosynthesis", or the "assimilation of carbon dioxide" is the biochemical process, in which simply constructed and relatively inert inorganic compounds are built up into the highly complex, reactive and sensitive organic compounds, which characterize living matter. Only living, active plant cells containing chlorophyll, and exposed to light, can perform this outstanding chemical feat. The phenomenon has been studied for a long time, and much detailed information has been gathered about it. Yet, the exact mechanism is still unknown, and the chemist cannot perform in his laboratory the same reactions with the same means, which the plants use on a gigantic scale every year.

Every living cell of any plant or animal requires energy in order to carry out its ordinary life processes, and it secures this energy from some organic material within the cell. This food material is in the last analysis always a product of photosynthesis. In the process of metabolism the oxygen of the air is used to oxidize the food, and carbon dioxide is eliminated. Oxygen intake, and carbon dioxide removal are carried on during the lifetime of the cell as respiratory activity.

In the form of a chemical equation the process of photosynthesis is usually written

[1]From the presidential address delivered at the Annual Meeting of The Ohio Academy of Science at Wittenberg College, Springfield, Ohio, on April 20, 1956.

$$\underset{\text{carbon dioxide}+}{x\ CO_2} + \underset{\text{water}+\text{light}}{x\ H_2O + \text{light}} \longrightarrow \underset{\text{carbohydrate}+\text{oxygen}}{(CH_2O)_x + x\ O_2}$$

while metabolic combustion is symbolized by

$$\underset{\text{carbohydrate}+\text{oxygen}}{(CH_2O)_x + x\ O_2} \longrightarrow \underset{\text{carbon dioxide}+\text{water}+\text{energy}}{x\ CO_2 + x\ H_2O + \text{energy}}$$

When a hexose sugar is used for the purpose of illustration, the two reactions may be represented as follows:

$$6\ CO_2 + 6\ H_2O + 672\ \text{kcal.} \underset{\text{Respiration}}{\overset{\text{Photosynthesis}}{\rightleftharpoons}} C_6H_{12}O_6 + 6\ O_2$$

During illumination of a plant the photosynthesis process is superimposed upon plant respiration, and the energy-storing activity exceeds the energy-consuming one manyfold. Both are responsible for the carbon dioxide cycle in nature, which involves the continuous regeneration of carbon dioxide, the most depreciated form of carbon, in form of energy-rich organic compounds and of oxygen. The latter will then be available to plants and animals for the vital activity of cell respiration.

In order to present a picture of the magnitude of the energy storing process, it may be mentioned that our present civilization derives more than ½ of its mechanical and heat energy from photosynthesis, either from food materials and from wood produced now, or from fossils like coal, oil, or natural gas, which are only the still available end products of the same process, when it took place in geological ages. Chlorophyll derivatives have been identified in small amounts in shale oils, petroleums, asphalt, and other bituminous deposits as well as in certain coals; these findings have confirmed the geological and paleobotanical views that these fossils are of plant and not of animalic origin. Incidentally, these discoveries also demonstrate that the plants growing in the Silurian period of the Paleozoic era—about 350 to 400 million years ago—contained the same chlorophyll which our plants produce.

The numerous chemical reactions involved in photosynthesis and in respiration are catalytically controlled: the green coloring matter of the plants governs the uptake of radiant energy, and a red pigment directs the oxygenation of blood in the lungs of animals. These pigments have been the objects of long and intensive studies. Pelletier and Caventou extracted the green matter from plants in 1818, and named it chlorophyll, but only in 1906 did M. Tswett definitely establish by chromatography that many plants contained actually two green pigments. He also isolated a number of yellow and orange-red pigments, which accompanied the green ones. At the beginning of this century Willstätter demonstrated the chemical identity of the chlorophylls irrespective of the plant from which they were isolated. Further work established that the ratio of the blue-green chlorophyll *a*, $C_{55}H_{72}N_4O_5Mg$, to the yellow-green chlorophyll *b*, $C_{55}H_{70}N_4O_6Mg$, was usually about 2.5 or 3 to 1, but that in some plants the *b*-component was entirely lacking. Improved experimental techniques also ascertained the ratio of the yellow pigments carotene to xanthophyll in green leaves as 1:2, and demonstrated the presence of several other pigments in plant tissue. So far no plant containing chlorophyll *b* only has been found.

If one pours defibrinated beef blood into hot glacial acetic acid, which has been saturated with sodium chloride, one obtains, upon cooling, beautiful dark red brown crystals. They represent the coloring matter from blood, and were called "hemin". The method described yields a chlorine-containing product, while the hemoglobin of the blood, from which the hemin was formed, is chlorine-free. Thus hemin is an artificial product. Its formula is $C_{34}H_{32}N_4O_4FeCl$. Hemoglobin

of the red blood corpuscles of human blood consists to 96 percent of the histone globin, and to 4 percent of pigment. In the animal kingdom hemoglobin is the most common respiratory pigment. Its all important property is its ability to react reversibly with oxygen, taking it up in the lungs at a certain pressure, and releasing it later in the tissues under diminished pressure. In this "oxygenation" the valency of the iron atom remains +2. Oxyhemoglobin has a characteristic two-banded absorption spectrum, while the oxygen-free hemoglobin exhibits a spectrum with only one rather diffuse absorption band.

The globin portion in the hemoglobin of different animals is typical for a particular species. The hemoglobins show differences in crystal form, solubility, molecular weight, and sometimes in the absorption spectra. The percentage of the component amino acids and consequently the electrochemical behavior, as well as immunological reactions vary also. But the pigment component, the so-called prosthetic group, is in all cases the same. Thus hemin prepared from human blood is identical with hemin obtained from the blood of cattle.

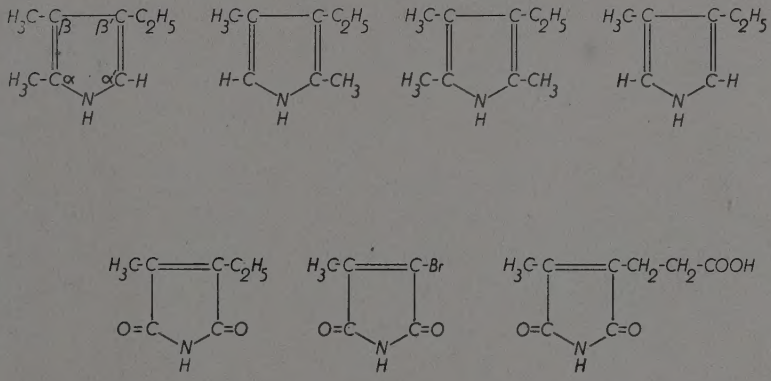

FIGURE 1. Cleavage Products. Reductive cleavage products* (Top row) from left to right, hemopyrrole, cryptopyrrole, phyllopyrrole, and opsopyrrole; oxidative cleavage products (Bottom row) from left to right, methyl ethyl maleic imide, bromo citraconic imide, and hematinic acid.

*In the corresponding carboxylic acids the ethyl group,—C_2H_5, is replaced by the propionic acid group,—CH_2—CH_2—COOH.

In the human organism the red blood corpuscles as living cells are continuously produced, they grow to maturity, and die after a certain life span. The pigment component is then also decomposed, and eliminated in form of bile pigment, while the iron is retained to be available for the synthesis of red pigment of young blood cells. Indeed the output of bile pigment has been used to gain information about the rate of decomposition of red blood corpuscles in the human body at the time, before radioactive tracer elements were available for such investigations.

An interesting similarity of hemin and chlorophyll lies in the fact that these important bio-catalysts contain a metal atom complexly linked to the pigment molecule, and that they occur in nature as chromo-proteides: to the pigment + protein combination hemoglobin corresponds in the plant the chlorophyll + protein union, for which most commonly the term chloroplastin is used.

Hans Fischer concentrated his studies upon the pigment components of these pigment + protein compounds. He was able to elucidate the chemical relationship of hemin and chlorophyll by degradation and synthetic investigations, which

extended over about 30 years. Drastic reductive cleavage of derivatives of hemin and of chlorophyll with hydriodic acid in glacial acetic acid yielded substituted pyrroles: bases, which carried in their β-positions one methyl and one ethyl group each, and the corresponding carboxylic acids with methyl and propionic acid residues in these positions. Total oxidation with CrO_3 or with PbO_2 resulted in products, for which the same principle of substitution was valid, again from either of the two pigments.

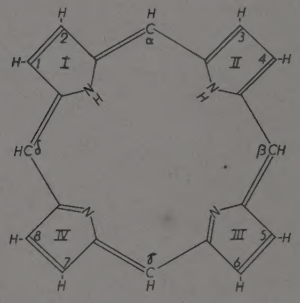

FIGURE 2. Porphin and nomenclature.

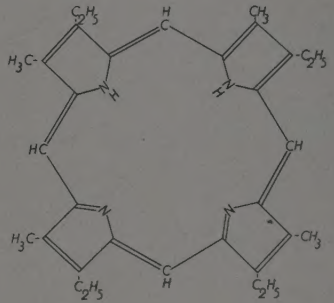

FIGURE 3. Etioporphyrin III.

Four of such nitrogen-bearing five-membered rings were present, linked in their α-positions by $-\overset{H}{\underset{}{C}}=$bridges. For the unsubstituted ring system Fischer suggested the name "porphin". Its structural formula and the conventional nomenclature for it are given in figure 2.

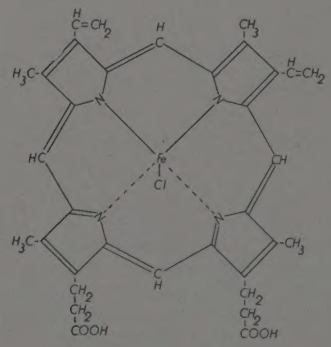

FIGURE 4. Hemin.

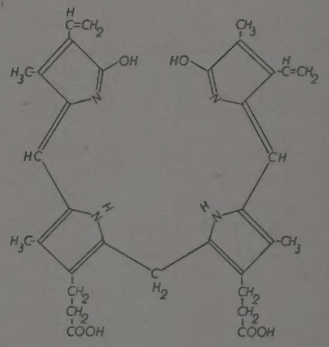

FIGURE 5. Bilirubin.

All identifying marks are counted in clockwise direction. Starting with the ring in the left upper corner the rings are given Roman numerals I to IV, and beginning on the same ring, the hydrogen atoms in the β-positions are designated by Arabic numbers 1 to 8. Hydrogen atoms on the bridge carbon atoms receive lower case Greek letters α to δ, starting between rings I and II.

Porphin, the fundamental ring system in hemin as well as in chlorophyll can be synthesized from pyrrole and formaldehyde, or from pyrrole-α-aldehyde. Controlled degradation reactions on hemin and on chlorophyll resulted in the isolation of numerous substituted porphins. Many of them exhibit in neutral ether solution a beautiful porphyry-red color. On account of this property all substituted porphins, and porphin itself, have been given the collective designation "porphyrins".

The decomposition of hemin may be performed to yield a porphyrin of the following structure,

If one stays within the limitation for the substituents presented above, viz. one methyl and one ethyl group only on each pyrrole ring, then there are only four isomers possible. They were given the name etioporphyrins, and their structural arrangement of substituents may be tabulated as follows:

Isomer	Location of Substituents	
	CH_3	C_2H_5
I	1.3.5.7	2.4.6.8
II	1.4.5.8	2.3.6.7
III	1.3.5.8	2.4.6.7
IV	1.4.6.7	2.3.5.8

It should be noted that the Roman numbers for these etioporphyrins were arbitrarily assigned during Hans Fischer's investigations of these compounds. It was found that the etioporphyrin from hemin, the "natural etioporphyrin" followed the arrangement assigned as structure for the isomer III. For an arrangement of four like substituents, and two pairs of different ones, 15 isomers are found. Thus, when one eliminates the > Fe-Cl grouping in hemin and replaces it by two hydrogen atoms, one obtains the so-called protoporphyrin IX, which has its four methyl groups in 1.3.5.8-positions, and belongs therefore to the isomer type III. This porphyrin carries two vinyl groups $-\overset{H}{\underset{C}{}}=CH_2$ in positions 2, and 4, and two propionic acid residues, $-CH_2-CH_2-COOH$ in positions 6, and 7.

The structure of hemin, as established by Hans Fischer's synthesis, is

In the bile pigment bilirubin, $C_{33}H_{36}N_4O_6$, the common structure with hemin is still recognizable, when it is written as in figure 5, although the main ring has been opened.

As already mentioned this break of the ring is performed continuously in the animal organism, apparently with great ease. In vitro the cleavage of the porphin ring system to obtain compounds of the type of bile pigment can be performed, but is experimentally far from simple. Yet in the living organism it may be also brought about mechanically: a short blow of proper intensity in the right location will promptly initiate the reaction, the beautiful color scheme of the "black and blue mark" demonstrates its progress in the decomposition of blood pigment to bile pigments. With a faint yellow the ultimate absorption of the pigments is in due time terminating.

The chlorophylls are also patterned according to the arrangement of substituents in the isomer type III, as the following formula for chlorophyll *a* indicates: Chlorophyll *b* carries in position 3 an aldehyde group (=formyl group) $-\overset{H}{\underset{C}{}}=O$, where n the *a* component a methyl group is located. The total synthesis of the chlorophylls has not been performed as yet, although all the fundamental work to accomplish this task seems to be available. Figure 6 represents the most

likely picture of the structure according to our present knowledge of the molecule. The fundamental differences between hemin and chlorophyll—other than the fact that one is an iron, the other a magnesium complex salt—may be summarized as follows: in chlorphyll *a* an ethyl group replaces one vinyl group in position 4, the double bond between carbon atoms 7 and 8 in hemin is hydrogenated in chlorophyll; chlorophyll is complicated by the 6, γ-ethanone ring, which carries a methyl ester group, its propionic acid group in position 7 is esterified by the unsaturated aliphatic alcohol phytol, $C_{20}H_{39}OH$. It is interesting to note that this alcohol is also a constituent of the natural vitamin K. Hemin is a dicarboxylic acid, chlorophyll an ester of an acid of high molecular weight with an alcohol of high molecular weight, which accounts for its character as a waxy material, which is difficult to obtain in crystallized form. Hemin and chlorophyll are porphin pigments, but the bile pigment with its opened porphin ring and the linear arrangement of the four pyrrole rings no longer belongs to this class of pigments.

A very close relationship exists between hemin and chlorophyll on one hand, and bacteriochlorophyll *a* from certain microorganisms on the other:

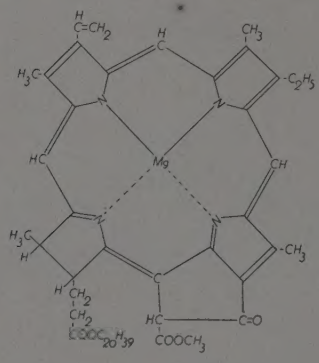

FIGURE 6. Chlorophyll *a*.

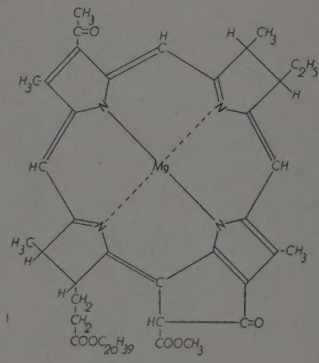

FIGURE 7. Bacteriochlorophyll *a*.

The comparison of its structure with that of chlorophyll *a*, Fig. 6, shows that two pyrrole rings are partially hydrogenated, and the vinyl group in position 2 has been replaced by an acetyl group $-\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}=O$.

Another porphin pigment, closely related to hemin and to chlorophyll, occurs in plants in extremely small quantities, namely the oxygen-transfering respiratory cell "ferment", the "cytohem" of Warburg. It is of hemin type, a porphyrin-iron complex, linked to protein in the cells, and of paramount importance in cell respiration. Cytohem is at present the subject of intensive studies on four continents. It has been demonstrated that Vitamin B_{12} is also related to hemin and chlorophyll structurally. For comparison the formula of the hexacarboxylic acid from this vitamin is given in figure 8.

The differences are already more pronounced: the $-\underset{\displaystyle H}{\overset{\displaystyle |}{C}}=$ bridge between rings I and IV is replaced by a single bond, hydrogenations have modified the ring system greatly; in addition to methylations and carboxylations the complexing metal

in the molecule is cobalt, linked to chlorine, and to the nitrile group, in addition to its linkage to one of the nitrogen atoms of one of the four five-membered rings.

A few more experimental facts concerning the pigments hemin and chlorophyll may be inserted here to illustrate their chemical behavior. Treatment of hemin with certain acids removes iron and chlorine under porphyrin formation. The various porphyrins so obtained can be recognized by their characteristic absorption spectra. Introduction of the > Fe-Cl group into protoporphyrin IX yields the natural hemin. When the same reaction is used on other porphyrins, the corresponding iron chlorides are formed. They have received the class designation "hemins" to indicate their structural analogy to hemin from blood.

If either of the two natural chlorophylls is exposed to even very dilute acids, the magnesium atom in the molecule is replaced by two hydrogen atoms. Suitable reagents allow to introduce magnesium again into the magnesium-free pigments, and the original chlorophylls are restored. Controlled chemical decomposition of

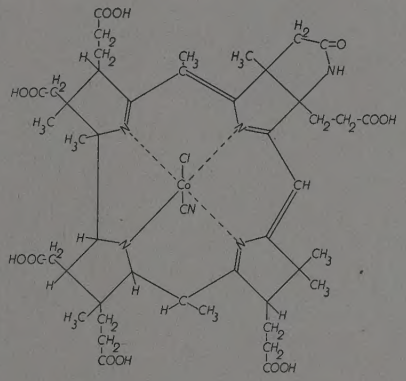

FIGURE 8. Hexacarboxylic acid from Vitamin B_{12}.

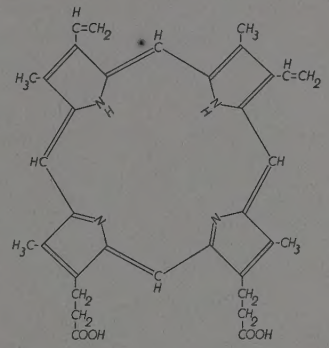

FIGURE 9. Protoporphyrin IX.

the chlorophylls yields numerous magnesium-free compounds of porphyrin type, and even those, which are structurally intermediates between the chlorophylls and the porphyrins. Into their molecules magnesium may also be built again. It is even possible to degrade the chlorophylls to the porphyrin stage without eliminating the magnesium in the process. The name "phyllins" is applied to all such magnesium complex salts which are still structurally closely related to the chlorophylls.

The synthetic efforts of the modern chemist have by far outdone Nature in the number and types of porphyrin compounds, which have been synthesized. Much of this work was, and is still at present, undertaken in order to elucidate the steps by which the organisms perform syntheses of pigments of porphin type.

Obviously the last steps in these syntheses in nature are the introduction of the metal, iron or magnesium respectively, and the attachment of the prosthetic group to the protein molecule, but the methods of the physiological syntheses of such complicated pigments have not been learned so far. Studies of the subject are rendered more difficult yet because in the tissues of animals and plants the normal concentration of porphyrins is very low. The isolation of possible precursors of hemin or chlorophyll can take advantage of the availability of several reliable tests for porphyrins and their complex salts. The solutions of these compounds fluoresce characteristically pink or red under ultraviolet radiation.

Differences in basicity toward hydrochloric acid permit separation and identification of many pigments by fractionating them with selected concentrations of this acid. Other suitable techniques for separation are chromatography and electrophoresis. The isolated pigments have often characteristic melting points. The latter determinations may be improved for porphin carboxylic acids by also determining the melting points of their esters. Of great aid in this field are the optical properties of the entire class of compounds: solutions exhibit absorption or fluorescence bands, whose wavelength ranges and intensities allow often the positive identification of several pigments in a mixture. Many substances also have typical powder spectra. Some of the naturally occurring materials, like the chlorophylls, have asymmetric carbon atoms in their molecules, and rotate the plain of polarized light.

In order to stress the need of reliable determination of these compounds the topic of porphyrins in health and disease may be briefly surveyed. Such a discussion will underscore the importance of hemin and chlorophyll for life on earth. The pigments derived from them are commanding ever increasing attention, especially since failure of the animal organism to synthesize hemin properly leads to a number of startling, dangerous, and oftentimes fatal conditions.

Porphyrins and their metal complex salts occur in nature normally in small quantities only. The green leaves and other green parts of plants contain them; they are found in many foods, in bread, fish, and milk, also in beer. Relatively high is their content in potatoes, rutabagas, and in spinach. In the animal the young cells of the erythrocyte series, and the bone marrow possess porphyrins. The spotted egg shells, and the feathers of certain species of birds owe their color to free porphyrins, or to their metal complex salts. Naturally occurring porphyrins and porphyrin derivatives are of the types I, or III, as outlined in the table on page 197. Due to the complicated structure of these compounds it cannot be assumed that the two different types arise from one common prototype, or that one type alone is synthesized and changed by chemical means into the other in the body. Independent synthesis of the two types from simple pyrroles must take place by mechanisms still unknown. This concept was first pronounced by Hans Fischer as the "dualism of porphyrins in nature". In human hemoglobin the ratio of type III to type I is greatly in favor of type III, about 10,000:1, and this almost exclusive synthesis of the isomer pattern III is normally very strictly maintained, as far as the blood pigment is concerned. The "natural" protoporphyrin IX (type III), into which iron is introduced in the synthesis of the prosthetic group of hemoglobin, is present in human blood (8 to 15 micrograms per 100 ml.). The formulae of two closely related porphyrins, coproporphyrin (fig. 10) and uroporphyrin (fig. 11) are given due to their importance in nature. In both figures the types III have been represented to show the relationship to protoporphyrin IX (fig. 9). Uroporphyrins are tetraacetic acid-tetrapropionic acid porphins, coproporphyrins are easily obtained from them by decarboxylation and are tetrametyl-tetrapropionic acid porphins. A human adult excretes in urine during a 24 hr. period normally 12 to 100 micrograms coproporphyrin, and usually it is stated that about 80 percent of this quantity belong to type I, and 20 percent to type III. Some authors claim, however, absence of type III; in one case a large quantity of pooled urine (10,000 liters) was analyzed and the coproporphyrins I and III were found in a ratio of 1 : 1. It has been suggested that this result may have been caused by the inadvertent admixture of pathological urines of undiagnosed cases with higher coproporphyrin III content in the material examined.

Human bile and human feces contain normally coproporphyrin I. The total urinary and fecal excretion of coproporphyrin for human adults is between 150 and 350 micrograms per day. Infants and children eliminate smaller amounts. Uroporphyrins are absent from normal urine; the role of uroporphyrin in the synthesis of the pigment component of hemoglobin has recently been discovered,

and it seems that all of the uroporphyrin is used up so promptly that no excretion takes place.

Under pathological conditions the amounts of porphyrins excreted are increased, and the ratios of the isomers are altered also. Thus, in certain hepatic diseases coproporphyrin I is found in the urine almost exclusively, and in greatly increased amounts, while in alcoholic cirrhosis coproporphyrin III causes the larger content of urinary porphyrin. Coproporphyrin III is present in the urine in most cases of acute poliomyelitis, and of poisoning by certain elements, or drugs. Out of the long list of such materials only a few may be given here: arsenic, phosphorus, lead and selenium, acetanilide, aspirin, barbiturates, ethyl ether, morphine, phenacetine, salvarsan, and the sulfa drugs. Coproporphyrin I elimination exceeds that of coproporphyrin III in many febrile conditions, and in certain blood diseases.

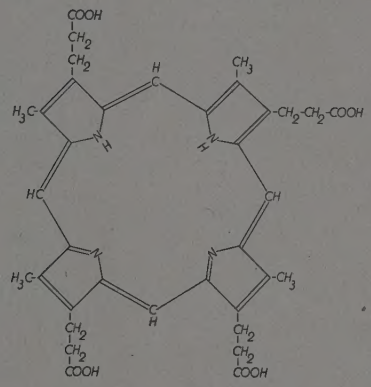

FIGURE 10. Coproporphyrin III.

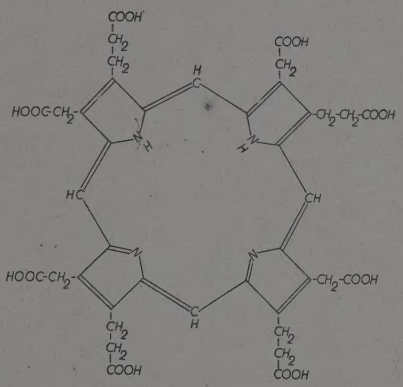

FIGURE 11. Uroporphyrin III.

In addition to these causes for increased temporary porphyrin excretion in urine (porphyrurias), the conditions of congenital defective porphin pigment metabolism, the porphyrias, must be mentioned. Patients with congenital porphyria excrete large amounts of type I porphrins, so much in some cases, that the urine is of deep Burgundy-red color, and they are very sensitive to light. This rare recessive metabolic error is found more frequently in men than in women (ratio about 2 : 1). The sensitivity of the skin to light causes itching, erythema, blister formation on the exposed areas (usually face and hands), and skin eruptions, which leave pigmented scars. Necrosis of the tissues involved leads to severe and disfiguring destructions, especially of the thinner parts of the body, where light could penetrate from different directions, like ears, nose, and fingers. Often blindness is observed due to scar formation. The bones and teeth become discolored due to impregnation with porphyrin. Neither cause nor cure for the disease are known. The disease is also well known in animals (ochronosis of cattle, pigs, and squirrels).

The so-called "acute porphyria" is also a disorder of the porphin pigment metabolism, inherited as Mendelian dominant in the ratio of ♀ : ♂ about 4 : 1. It is more common than the congenital form, usually in the ages between 30 and 50 years, and is rare in children. There is neither sensitivity to light, nor discoloration of skin, or bones, or teeth, but many other intermittent acute symptoms, like abdominal pain, constipation, vomiting, elevated blood pressure, and, very

characteristically, nervous and mental manifestations are observed. Progressive paralysis, and sometimes polyneuritis, effect a mortality of about 50 percent among individuals with nervous symptoms. Still more important is the fact that the mental picture in acute porphyria may resemble almost any type of psychic disorder. During an attack the urine is colored red or deep yellow, and contains a porphyrin of type III with only 7 carboxyl groups as compared with the 8 groups of this kind in uroporphyrin. Uroporphyrin I and coproporphyrin I are also found. Often the porphyrin is present as the zinc complex salt. During the intervening periods of time the urine carries so little of these pigments that its color is normal. But their presence reveals that the disease, though called "acute", is actually a chronic one. In latent cases of "acute porphyria" the therapeutic application of certain drugs, like the ones mentioned above, may cause all the manifestations of the disease, including the mental symptoms. It has been pointed out in the medical literature that the neuropsychiatric aspects of this form of porphyria have often been overlooked, and that many patients have been considered psychoneurotic for many months, and even years, before the diagnosis of porphyria was made. Furthermore, some of the drugs commonly used as sedatives may actually trigger off a porphyria of the "acute" type with all its nervous symptoms. Hayman has in this connection suggested "That the psychiatrists might run a few more urine analyses before embarking on extensive psychotherapy seems eminently sound." No effective treatment is known for the form of abnormal pigment metabolism called "acute porphyria".

Porphyrin solutions fluoresce, that is the incident radiation of a given wavelength is transformed in part into radiant energy of another, usually longer, wavelength, and re-emitted in that form. This transformer effect is common to all fluorescent materials, though to different degrees, and causes the phenomenon of rendering organisms sensitive to light. For example, Paramecium in weak eosin solution will be killed, when the suspension is exposed to visible light. The intensity of the photosensitizing effect of different porphyrins varies; in man it decreases for the same quantity of porphyrin per kg. body weight as follows: uroporphyrin I > coproporphyrin I > coproporphyrin III. In injection experiments with different species of animals the entire range of effects from slight skin irritation to lethal "light shock" has been produced. It should be mentioned that only white, or light colored animals with clean skin or fur show sensitivity to light from fluorescent pigments. Animals with dark fur, or those with white fur not freshly washed, will not react to exposure to light. In our civilization there are many possibilities for the individual to come in contact with water-soluble fluorescent dyes, *e. g.*, red pigment from lipstick, or dyes from other cosmetic preparation, dyes of many different colors from garments may enter the body through smallest abrasions or through cuts in the skin in minute quantities. The ensuing symptoms may be pronounced "allergic", until the response to the radiation of the sun is noticed. In such cases the search for the offending dye, and its removal, will alleviate the symptoms, and as the pigment is eliminated from the body, the sensitivity to light will disappear completely, and with it the allergic manifestations.

The purpose of this brief presentation was to show the importance of the pigments hemin and chlorophyll to our lives. Today we recognize them primarily for their role in respiration and in photosynthesis. But if and when these two vital processes become completely understood, the field of porphin pigments will not have lost either importance, or attractiveness for further research. On the contrary, the relationship of these pigments to other fields of organic and biochemistry, and their metabolism in health and disease, will continue to pose a multitude of new questions and problems for further study.

MACROMIA ALLEGHANIENSIS WILLIAMSON IN OHIO WITH NEW RECORDS OF OTHER ODONATA IN OHIO

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In the course of working on the Williamson-Kennedy Collection of Odonata in the University of Michigan Museum of Zoology (UMMZ) for the purpose of revising the list of Michigan Odonata a number of unpublished records of Ohio Odonata were found. Some of this material apparently was not available at the time Borror prepared his list of Ohio dragonflies (Borror, 1937). Additional records were found, including that of a species new to Ohio, *Macromia alleghaniensis*, among the undetermined material from Ohio acquired in the collections of the late Dr. Clarence H. Kennedy and the late Dr. Mike Wright. Dr. T. H. Hubbell, Director of the UMMZ, kindly permitted my use of the collection for this paper.

In the following list the species are numbered in accordance with the several previous papers on Ohio Odonata the most recent of which is that of Price (1950). Names of collectors are given in parentheses after the county record and are abbreviated as follows:

BEM—B. Elwood Montgomery
CHK—Clarence H. Kennedy
DSK—D. S. Kellicott
EBW—E. B. Williamson
GWB—George W. Byers
HRW—H. R. Watts
IJC—Irving J. Cantrall
JJF—James J. Friauf
JSH—J. S. Hine
MW—Mike Wright
RCO—R. C. Osburn
RRD—R. R. Dreisbach

LIST OF SPECIES

8. *Gomphus* (*Gomphurus*) *crassus* Hagen. Madison (CHK).
9. *Gomphus exilis* Selys. Columbiana (EBW).
10. *Gomphus* (*Gomphurus*) *fraternus* (Say). Knox (no collector), Licking (CHK), Lucas (EBW), Madison (CHK), Morgan (DSK).
14. *Gomphus lividus* Selys. Columbiana (EBW), Madison (CHK).
17. *Gomphus quadricolor* Walsh. Ashland (EBW).
20. *Gomphus* (*Gomphurus*) *vastus* Walsh. Knox (no collector).
22. *Gomphus* (*Arigomphus*) *villosipes* Selys. Hamilton (EBW), Mahoning (EBW).
28. *Basiaeschna janata* (Say). Columbiana (EBW).
31. *Anax junius* (Drury). Columbiana (EBW).
37. *Aeshna mutata* Hagen. Logan (EBW).
43. *Cordulegaster obliquus* (Say). Medina (JSH).
139. *Macromia alleghaniensis* Williamson. A state record. Two males of this distinctive species were taken by the late Dr. Kennedy at the Put-In-Bay Lake Laboratory (Ottawa County) on Lake Erie during the summer of 1934. No specific dates are listed with the data. The distribution of this species is interesting in that except for a record from Kentucky it has been taken only in the coastal states from Pennsylvania and New Jersey to Alabama. Whether this species has become permanently established in Ohio remains to be seen.
46. *Didymops transversa* (Say). Columbiana (EBW).
49. *Epicordulia princeps* (Hagen). Hamilton (EBW).
55. *Celithemis elisa* (Hagen). Hamilton (EBW).
57. *Celithemis monomelaena* Williamson. Ashland (EBW).

65. *Plathemis lydia* (Drury). Columbiana (EBW).
66. *Libellula pulchella* Drury. Hamilton (EBW).
68. *Libellula semifasciata* Burmeister. Knox (EBW), Logan (EBW).
73. *Sympetrum rubicundulum* (Say). Columbiana (EBW), Harrison (GWB), Hocking (MW).
76. *Sympetrum vicinum* (Hagen). Columbiana (EBW), Harrison (GWB).
77. *Leucorrhinia intacta* (Hagen). Columbiana (EBW).
83. *Tramea lacerata* Hagen. Hamilton (EBW).
87. *Calopteryx maculatum* (Beauvois). Lawrence (JSH), Mahoning (EBW).
88. *Hetaerina americana* (Fabricius). Columbiana (EBW).
91. *Lestes congener* Hagen. Delaware (MW).
96. *Lestes rectangularis* Say. Fulton (JSH).
97. *Lestes dryas* Kirby. Fulton (JSH).
102. *Argia moesta* (Hagen). Huron (RRD), Monroe (MW).
104. *Argia tibialis* (Rambur). Ashland (CHK), Lawrence (JSH), Mahoning (EBW).
108. *Nehallenia irene* (Hagen). Ashland (EBW).
109. *Chromagrion conditum* (Hagen). Ashland (EBW), Columbiana (EBW), Knox (EBW).
111. *Enallagma aspersum* (Hagen). Mahoning (EBW).
113. *Enallagma carunculatum* Morse. Summit (JSH).
114. *Enallagma civile* (Hagen). Hamilton (EBW).
115. *Enallagma divagans* Selys. Columbiana (EBW).
117. *Enallagma ebrium* (Hagen). Lucas (EBW).
118. *Enallagma exsulans* (Hagen). Summit (JSH).
119. *Enallagma geminatum* Kellicott. Hamilton (EBW), Henry (JSH).
124. *Ischnura posita* (Hagen). Columbiana (EBW).
126. *Ischnura verticalis* (Say). Columbiana (EBW).

The extensions of seasonal range as ascertained in this review are as follows (the species are numbered as above):

10. *Gomphus* (*Gomphurus*) *fraternus* (Say). April 26, 1941 (Franklin, MW).
13. *Gomphus* (*Gomphurus*) *lineatifrons* Calvert. June 17, 1935 (Franklin, IJC).
15. *Gomphus* (*Stylurus*) *notatus* Rambur. June 1, 1899 (Lawrence, RCO).
17. *Gomphus quadricolor* Walsh. June 19, 1900 (Portage, RCO).
18. *Gomphus spicatus* Hagen. July 10, 1899 (Erie, RCO).
20. *Gomphus* (*Gomphurus*) *vastus* Walsh. July 17, 1920 (Ottawa, CHK).
22. *Gomphus* (*Arigomphus*) *villosipes* Selys. June 25, 1904 (Hamilton, EBW).
48. *Neurocordulia yamaskanensis* (Provancher). June 29, 19— (Ottawa, CHK).
57. *Celithemis monomelaena* Williamson. June 9, 1915 (Ashland, EBW).
60. *Ladona julia* (Uhler). June 23, 1898 (Portage, JSH).
63. *Libellula incesta* Hagen. June 19, 1899 (Erie, RCO).
73. *Sympetrum rubicundulum* (Say). October 10, 1901 (Columbiana, EBW).
90. *Archilestes grandis* (Rambur). August 24, 1939 (Butler, BEM).
92. *Lestes disjunctus australis* Walker. April 20, 1941 (Franklin, MW).
95. *Lestes inaequalis* Walsh. May 31, 1941 (Logan, HRW).
104. *Argia tibialis* (Rambur). May 27, 1899 (Lawrence, JSH).
110. *Enallagma antennatum* (Say). September 24, 1938 (Lucas, JJF).
115. *Enallagma divagans* Selys. July 4, 1930 (Logan, EBW).

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CRATAEGUS IN OHIO WITH DESCRIPTION OF ONE NEW SPECIES

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This review of *Crataegus* in Ohio has been made in cooperation with the Ohio Flora Committee of the Ohio Academy of Science as a contribution to their forthcoming flora of the state. Many of the universities and colleges of the state have sent collections of herbarium specimens to me for examination, and information has been drawn from these and other sources including some private collections. The large collection in the herbarium of the Ohio State University, covering most of the state, has been particularly helpful. Other institutions sending large collections were the University of Cincinnati, Oberlin College, Miami University, and Defiance College. Dr. E. Lucy Braun also sent many interesting collections from her private herbarium; and she has given invaluable assistance in outlining the work and in cooperating with it in many ways. In addition to the larger collections mentioned above, specimens have been received from Ohio University, Dennison University, Kent State University, Antioch College, and from the private collection of Mr. John Guccion of Cleveland. Dr. Gerald B. Ownbey also sent a number of collections from Ohio deposited in the herbarium of the University of Minnesota. The large amount of material from Ohio in the herbarium of the Arnold Arboretum, Jamaica Plain, Massachusetts, was also checked, including duplicates of many of the collections seen in Ohio herbaria, and also fuller collections made by R. E. Horsey in many parts of the state, and by F. J. Tyler, Harry Crowfoot, and C. C. Clevenger, mostly in Lake and adjoining counties. Many other scattered specimens have also been received and checked.

But after examining all of these records it is obvious that much remains to be done before a complete list of the *Crataegus* flora of the state can be made, or anything like full data on the distribution of the species in the state can be given. It is possible that some species of *Crataegus* are indigenous in every county; several of the commoner species, such as *Crataegus crus-galli* and *C. punctata* have a statewide distribution and might be expected in nearly if not all of the counties. *C. mollis*, generally on calcareous soil, is almost limited to western Ohio where calcareous soils prevail; there, it is in almost every county. At present there are a number of counties from which we have no records. This is no doubt due to the fact that botanical interest and collecting is always sporadic and unevenly distributed. Full and systematic collecting is usually limited to the vicinities of the larger educational institutions or of the homes of amateur botanists. What is done in other sections is occasional and scattered.

Crataegus is the largest genus of woody plants found in Ohio; and this also holds true for the entire United States. Nearly all of the species are small trees or arborescent shrubs found growing in thickets or on the borders of woods, and they have often become established in pastures and along fencerows. Their dispersion is probably largely due to birds that feed upon the fruit and deposit the undigested seeds in their droppings. Since most of the species cannot stand the competition of larger trees, the genus is rare or absent in densely forested areas; there are fewer records from wooded eastern Ohio than from agricultural western Ohio. It is certain that there has been a very great increase in individuals and in the areas available to them since much of the country has been cleared and brought into cultivation. The changed conditions and increased

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competition between the original species have probably resulted in the development of many new forms and hybrids.

While most species of *Crataegus* are not absolutely selective as to soil, they show a decided preference for alkaline soils, and they are most abundant and varied in limestone regions; this is well illustrated by the range of *C. mollis*. The *Crataegus* flora of Ohio is a large and diverse one due to the wide range of ecological conditions found in the state and to the fact that large areas are underlaid with

FIGURE 1

Crataegus Horseyi n. sp. a. Flowers and leaves of flowering branchlet. b. Leaf of vigorous terminal shoot, maximum size. C. Fruits. All figures natural size.

limestone or are covered with alkaline or neutral soils. The list contains 67 species, including 4 that are represented only by a variety other than the typical one, 30 additional varieties, 2 forms, and 4 unnamed hybrids. It is not unlikely that a few more might be added by further exploration. Three species, *Crataegus oxyacantha*, *C. monogyna*, and *C. prunifolia*, have been introduced, and are now

common in cultivation in both European and American gardens. The first two, commonly known as English Hawthorn, are natives of the Old World, and occur more or less frequently as escapes from cultivation. *C. prunifolia*, rarely occurring as an escape, was described from a tree found growing in a European garden, and appears to be a hybrid between two North American species, *C. crus-galli* and *C. Calpodendron* or a related species.

The hawthorns or red haws are amongst our most ornamental trees. Their profusion of fragrant blossoms, often opening before or with the leaves, their widely variable but often thick and glossy foliage, and the abundant usually bright-colored fruit, combine to make them attractive throughout the year. Another advantage that recommends them for planting is the abundant supply of bird food they supply. For the haws are eaten by birds not only at the time of ripening, but also later; the fruit of some species stays on the trees until late in the season, and often it remains on the ground through the winter, thus affording food for birds and small mammals when most other sources have been exhausted. For these reasons, a number of native species are now often planted in parks and private grounds, and particularly along parked roadways. American hawthorns were also early introduced into English and other European gardens, and they have long been more appreciated abroad than in their native country. The English hawthorn is also popular in cultivation here; in some forms the flowers are double, or are pink or red in color. It is famous in literature and folklore, and is closely associated with the Mayday festival and other holidays. It is commonly used for hedges in parts of rural England; some American species could be used to advantage where a dense ornamental hedge is desired.

The classification of *Crataegus* is one of the most puzzling and difficult in American botany. Botanists have disagreed widely as to how many species should be recognized and as to the value of the characters that have been used to distinguish them. Some species are well-marked and as easily recognized as species in other large genera. But in certain sections there is so much variability and merging of characters that it is most difficult to distinguish them, and it becomes a matter of opinion where the lines should be drawn between species. More than 1500 names have been proposed for American Crataegi, and most of these have been called species. But most students have come to believe that many of them can more properly be regarded as forms of variable species, that many are of hybrid origin, and others are transient sports or clones that could only be propagated vegetatively, and that can scarcely be called species as the term is generally understood. A considerable proportion of the proposed species are extremely local, and in some cases were known only from a single plant. The whole subject is a very complicated one and one in which there is much room for differences of opinion. Much more study and experimental work is needed to determine the validity and relationship of many species and forms. Any classification that has so far appeared can only be regarded as a tentative and provisional one.

The characters that have usually been used to distinguish species and other segregates in *Crataegus* are the shape, size, texture, and other variations in the leaves; the size and number of the flowers and their arrangement and structural parts, such as petals, sepals, stamens, anthers, and styles; the size, shape, color, and texture of the fruit; number and form of the nutlets; and size and form of the calyx. Of lesser importance but often described are the habit of growth, and characters of branches, bark, and thorns. All of these characters are variable and are combined with each other in various ways. In some cases, characters differ within the species, while in others some of them are sufficiently constant to differentiate the species. Much stress has been laid, especially by Sargent, on the number of stamens and the color of the anthers. But while they seem fairly

constant in some species they are not so in others; except where they are supplemented by other distinctions they cannot be relied on as specific distinctions. So until fuller information is available as to the origin and genetic relationships of the many intermediate forms, a conservative treatment seems most practicable and advisable.

CRATAEGUS L.

The name is from a Greek word signifying strength or invincibility; and it probably referred to the dense and thorny nature of the plants that made them immune from attack rather than to the strength of the wood, as has often been suggested. The plants are shrubs or small trees usually with crooked thorny branches. The leaves are alternate and vary greatly in shape and size in different species, and to some extent within the species. Terminal leaves of sterile shoots or of new and vigorous growth are often unlike those of the flowering branchlets. Such leaf specimens should never be collected for determination except in connection with flowering or fruiting material. The flowers are regular, normally with five petals and five to twenty stamens, and one to five styles. In most species they are several in number, borne in simple or branching corymbs or cymes, or rarely they grow singly or two or three in a close cluster. The fruit is a pome or haw with one to five bony nutlets embedded in the firm to succulent flesh. The fruits vary in shape from subglobose to oblong-cylindric, ovoid, or obovoid; they are sometimes slightly 5-angled. In our species, the color when ripe is some shade of red or more rarely yellow; but some species remain green and hard throughout the season. The fruit of some species is edible with a pleasing and distinctive flavor. While little use is made of it in this region, it has economic possibilities through selection and cultivation. One disadvantage is that is it commonly infested with the larva of a weevil; but this might be corrected by spraying.

For convenience, the genus has been divided into a number of groups or series that differ from each other in the degree of their distinctness of characters. Fourteen series are recognized as occurring in Ohio. A key to these, together with a list of the species, varieties, and forms under the different series is given below with essential synonymy and a list of the counties in which each has so far been found. Keys, descriptions of the series, and notes concerning the species will be published in the proposed Flora of Ohio. Several new combinations and the description of one new species are published here. Incomplete or inconclusive material examined indicates a few other unrecognized forms, species or hybrids.

KEY TO THE SERIES

a. Veins of the leaves running to the sinuses as well as to the points of the lobes; leaves mostly ovate or deltoid in outline, distinctly lobed; fruit subglobose, 4–10 mm. thick.
  b. Leaves often trilobate, up to 5–6 cm. long, thin, turning red or yellow in autumn, early deciduous; flowers in many-flowered compound corymbs, opening in late May or early June; fruit 4–6 mm. thick, bright red, becoming succulent, remaining on branches until late winter; nutlets 3–5. . . . . 1. CORDATAE
  bb. Leaves usually deltoid or broadly ovate in outline with 5–7 lobes, firm in texture, remaining green and persistent until late in season; flowers opening usually before middle of May; fruit firm or mellow at maturity, falling early; nutlets 1–2 or rarely 3. . . . . 2. OXYACANTHAE
aa. Veins of the leaves running only to the points of lobes or larger teeth; leaves entire or variously lobed; fruit subglobose, oval, ovoid, or pyriform, 0.5–1.5 cm. thick.
  b. Flowers single or rarely 2–3 in cluster; stamens 20–25; sepals foliaceous, pectinate; slender shrubs usually less than 1.5 m. tall. . . . . 3. PARVIFOLIAE
  bb. Flowers more numerous, in simple or compound corymbs or cymes; stamens 5–20; sepals entire or glandular-serrate, not foliaceous; trees or stout arborescent shrubs.
    c. Leaves of various shapes, cuneate to subcordate at base, glabrous or pubescent; fruit 0.5–1.5 cm. thick; nutlets 1–5, not pitted on ventral surface.
      d. Leaves mostly spatulate or obovate, broadest above middle except rarely on terminal shoots; unlobed or sometimes more or less lobed on terminal shoots.

e. Leaves firm to subcoriaceous, often glossy above, the veins inconspicuous or rarely slightly impressed above; flowers 1–1.5 cm. wide; fruit usually 1–1.3 cm. thick or less, with 1–2 or rarely 3–5 nutlets, remaining hard and inedible, usually dull red or green at maturity.....4. CRUS-GALLI

ee. Leaves firm but not subcoriaceous, dull above, the veins noticeably or conspicuously impressed above; flowers usually 1.3–2 cm. wide; fruit usually becoming mellow and somewhat edible; nutlets 3–5.....5. PUNCTATAE

dd. Leaves mostly rhombic, ovate, oblong-ovate, or deltoid in outline, broadest below or about middle, usually more or less lobed at ends of shoots.

e. Foliage and inflorescence glandular, often conspicuously so; leaves usually narrowed at base, except sometimes at ends of shoots; flowers mostly 3–8 in simple or little-branched corymbs; fruit usually remaining hard, green, bronze-yellow or dull red at maturity; branching shrubs, 1.5–3 m. tall.....6. INTRICATAE

ee. Foliage and inflorescence eglandular or sometimes sparsely glandular when young; flowers usually 8–15 or more in simple or compound corymbs.

f. Leaves mostly ovate, oblong-ovate, or elliptic in outline, abruptly narrowed or rounded at base, or sometimes deltoid or suborbicular at ends of shoots; fruit usually bright or dull red at maturity, firm to succulent; nutlets usually 3–5.

g. Leaves of flowering branchlets mostly oblong-ovate or rhombic, sometimes broadly ovate to suborbicular and rounded at base at ends of shoots, more or less incised with shallow or rounded lobes; flowers 1.2–1.5 cm. wide; nutlets 3–5.....7. ROTUNDIFOLIAE

gg. Leaves of flowering branchlets mostly ovate, rounded at base, those at ends of shoots similar but larger, slightly lobed below middle; flowers 1.5–1.8 cm. wide; nutlets usually slightly pitted on ventral surface, or sometimes plain.....8. BRAINERDIANAE

ff. Leaves mostly ovate, oblong-ovate, or deltoid in outline, rounded to truncate at base, or at ends of shoots broadly ovate to deltoid and often truncate to subcordate at base, more or less lobed; fruit 0.8–1.7 cm. thick; nutlets 3–5.

g. Leaves mostly ovate, more or less incised with acute lobes terminating in acuminate, often reflexed points, thin at maturity, glabrous except for short appressed hairs on upper surface while young; flowers 1.3–1.8 cm. wide; pedicels glabrous (except in *C. lucorum*); anthers pink; fruit 0.8–1.5 cm. thick, usually becoming mellow or succulent; nutlets 3–5.....9. TENUIFOLIAE

gg. Leaves mostly ovate or oblong-ovate, firm to thick at maturity, more or less incised, the points of lobes not reflexed; flowers 1.3–2.5 cm. wide; stamens 8–20; fruit 0.8–1.7 cm. thick; nutlets 3–5.

h. Petioles and midribs of leaves slender; flowers 1.3–2 cm. wide; filaments as long or nearly as long as petals; fruit 0.8–1.8 cm. thick, glabrous; nutlets 3–5.

i. Leaves glabrous or short-pilose above when young, glabrous beneath (except in *C. locuples*); fruit usually firm or hard at maturity, inedible; nutlets relatively large.

j. Leaves with short appressed hairs above while young, becoming glabrous; stamens 10 or less; fruiting calyx small and sessile.....10. SILVICOLAE

jj. Leaves glabrous or essentially so from the first (except in *C. locuples*); fruit often pruinose, sometimes slightly 5-angled, with prominent elevated calyx.....11. PRUINOSAE

ii. Leaves glabrous or pubescent; stamens 10–20; fruit usually becoming mellow and edible; nutlets relatively small.....12. COCCINEAE

hh. Petioles and midribs of leaves thick and prominent; filaments shorter than petals; fruit pubescent at least while young, 1.3–1.5 cm. thick, usually becoming mellow and edible; nutlets 3–5, usually 5.....13. MOLLES

cc. Leaves mostly ovate, oblong-ovate, or elliptic, abruptly narrowed or rounded at base, more or less lobed, glabrous except for short appressed hairs on upper surface while young; flowers mostly 4–14 in simple or little-branched corymbs; fruit hard or firm at maturity; nutlets 2–3 (or rarely more), deeply pitted on ventral surface.....14. MACRACANTHAE

SERIES I. CORDATAE

1. Crataegus Phaenopyrum (L.f.) Medic. (*C. cordata* Ait.)
   Belmont, Butler, Clinton, Guernsey, Hamilton, Jefferson, Montgomery, Preble.

SERIES II. OXYACANTHAE

2. Crataegus Oxyacantha L.
   Franklin, Lorain, Vinton, Williams. Native of Eurasia and the Mediterranean region.
3. Crataegus monogyna Jacq.
   Ashtabula, Cuyahoga, Geauga, Hamilton, Lake, Lorain, Medina. Native of Europe, north Africa, and western Asia.

SERIES III. PARVIFOLIAE

4. Crataegus uniflora Muenchh. (*C. trianthoflora* Sarg.)
   Adams, Meigs.

SERIES IV. CRUS-GALLI

5. Crataegus crus-galli L.
   a. var. crus-galli (*C. algens* Beadle, *C. arduennae* Sarg., *C. attenuata* Ashe, *C. eburnea* Ashe, *C. mollipes* Ashe, *C. trahax* Ashe)
      Adams, Athens, Auglaize, Brown, Butler, Clark, Clermont, Clinton, Coshocton, Cuyahoga, Defiance, Fairfield, Franklin, Gallia, Greene, Guernsey, Hamilton, Hardin, Highland, Jackson, Lake, Licking, Lorain, Mahoning, Meigs, Muskingum, Noble, Ottawa, Paulding, Richland, Scioto, Shelby, Stark, Summit, Union, Warren, Washington, Williams, Wood.
   b. var. barrettiana (Sarg.) Palmer (*C. barrettiana* Sarg.)
      Clinton, Erie, Franklin, Hamilton, Lawrence, Ottawa.
   c. var. exigua (Sarg.) Egglest. (*C. exigua* Sarg.)
      Ashland, Clark, Geauga, Hamilton, Harrison, Lucas, Tuscarawas.
   d. var. leiophylla (Sarg.) Palmer (*C. leiophylla* Sarg.)
      Franklin, Lake, Richland.
   e. var. pachyphylla (Sarg.) Palmer (*C. pachyphylla* Sarg.)
      Hamilton, Ottawa.
   f. var. pyracanthifolia Ait.
      Hamilton, Muskingum.
6. Crataegus Engelmanni Sarg.
   Richland.
7. Crataegus Fontanesiana (Spach) Steud. (*C. geneseensis* Sarg., *C. tenax* Ashe, *C. Wilkinsoni* Ashe)
   Auglaize, Butler, Crawford, Cuyahoga, Defiance, Lake, Ottawa, Perry, Richland, Scioto, Shelby, Tuscarawas, Wayne.
8. Crataegus hannibalensis Palmer
   Defiance.
9. Crataegus persimilis Sarg.
   Hamilton, Franklin.
10. Crateagus ohioensis Sarg.
    Franklin.
11. Crataegus pyracanthoides Beadle, var. arborea (Beadle) Palmer (*C. arborea* Beadle)
    Carroll, Lucas, Morgan, Ottawa.
12. Crataegus vallicola Sarg.
    Clark.

SERIES V. PUNCTATAE

13. Crataegus punctata Jacq.
    a. var. punctata
       Ashland, Ashtabula, Auglaize, Belmont, Brown Butler, Carroll, Clark, Clermont, Clinton, Columbiana, Coshocton, Cuyahoga, Defiance, Delaware, Fairfield, Fayette, Franklin, Fulton, Guernsey, Hamilton, Hancock, Hardin, Henry, Highland, Hocking, Holmes, Huron, Jefferson, Knox, Lake, Licking, Logan, Lorain, Lucas, Mahoning, Meigs, Monroe, Montgomery, Morrow, Muskingum, Noble, Ottawa, Portage, Preble, Richland, Ross, Seneca, Stark, Summit, Trumbull, Tuscarawas, Warren, Washington, Wayne, Williams, Wood, Wyandot.
    b. var. aurea Ait. (*C. crocata* Ashe)
       Clinton, Delaware, Fulton, Hamilton, Hardin, Lake, Mahoning, Ottawa, Paulding, Preble, Richland.
    c. var. canescens Britt.
       Crawford, Hancock, Hardin, Lorain, Medina.
    d. var. microphylla Sarg.
       Geauga, Lake, Wood.
    e. var. pausiaca (Ashe) Palmer (*C. pausiaca* Ashe, *C. calvescens* Sarg., *C. porrecta* Ashe)
       Fayette, Harrison, Jefferson, Lake, Licking, Miami.
14. Crataegus disperma Ashe (*C. cuneiformis* of Egglest., in part, *C. praestans* Sarg.)
       Ashland, Ashtabula, Auglaize, Butler, Clermont, Defiance, Erie, Fayette, Franklin, Hamilton, Lake, Licking, Madison, Portage, Richland, Shelby, Tuscarawas, Washington, Wyandot.
15. Crataegus Kellermanii Sarg.
       Fairfield, Franklin, Lake, Tuscarawas.
16. Crataegus mansfieldensis Sarg.
       Franklin, Richland.
17. Crataegus indicens Ashe
       Richland.
18. Crataegus peoriensis Sarg. (*C. grandis* Ashe, *C. pratensis* Sarg., *C. cuneiformis* of Egglest., in part)
       Franklin, Hamilton, Lawrence, Monroe, Ross.
19. Crataegus suborbiculata Sarg. (*C. Clintoniana* Sarg., *C. Brownietta* Sarg.)
       Ottawa.

SERIES VI. INTRICATAE

20. Crataegus intricata Lange
    a. var. intricata (*C. diversifolia* Sarg., *C. inducta* Ashe, *C. meticulosa* Sarg.)
       Adams, Fairfield, Franklin, Hocking, Knox, Meigs, Ottawa, Summit, Warren.
    b. var. straminea (Beadle) Palmer (*C. straminea* Beadle)
       Gallia.
21. Crataegus Boyntoni Beadle
       Adams, Guernsey, Lawrence, Morgan, Noble.
22. Crataegus rubella Beadle
       Athens, Hardin, Jackson, Summit.
23. Crataegus fortunata Sarg.
       Adams, Pickaway.
24. Crataegus Horseyi Palmer, sp. nov.
       Type locality, Gallia County.

Crataegus Horseyi sp. nov. Frutex circa 2–4 m. altus ramis sinuosis ascendentibus; ramulis gracilis fusco-rubris spiniferis. Spinae gracilae rectae aut leviter curvae fusco-purpureae 2–5 cm. longae, in ramulis infirmis ramosis. Cortex confertus fusco-canus. Folia glabra aliquantum tenues plerumque elliptica

aut oblongo-ovata apice acuta basi obtuso-cuneata ad attenuata, margine acuto-serratis superne obscuro-lobatis circiter 2–4 cm. longis 2–3.3 cm. latis. Folia circulorum ovata basi rotunda perspicue lobata firma 5–6 cm. longa 4–6 cm. lata. Petioli gracili glandulosi superne alati 1–2 cm. longi. Flores 1–1.3 cm. lati plerumque 3–5 in corymbis glabrescentis simplicibus; pedicellis .9–1.2 cm. longis; staminibus 5–10 saepe 5; antheris rubicundus; stylis plerumque 3; sepalis lanceolatis margine fere integris aut incomposite glandulo-serratis; bractis linearis stipito-glandulosis. Fructus subglobosi 6–9 mm. lati fusco-viridi vel tandem rubicunduli firmi calyce prominente efferto tubo brevi; semenibus plerumque 3.

A shrub 2–4 m. tall usually with several crooked ascending stems and slender thorny branchlets. Thorns sometimes compound on the older stems, slender, straight or slightly curved on branchlets, 2–5 cm. long. Bark close, dark gray. Leaves glabrous, those of the flowering branchlets mostly elliptic or oblong-ovate, pointed or short acuminate at apex, cuneate or attenuate at base, sharply serrate with fine gland-tipped teeth reduced to glands near base of blades, slightly or obscurely lobed above the middle. Petioles slender, ¼ to ⅓ as long as the blades, glandular, slightly wing-margined above. Flowers 1–1.3 cm. broad in simple mostly 3–5 flowered glabrous corymbs; pedicels .9–1.2 cm. long; stamens 5–10, often 5; anthers pink; styles usually 3; sepals lanceolate from a broad base, the margins nearly entire or irregularly glandular-serrate. Bracts conspicuous at flowering time, linear, thickly set with stalked glands on the margins. Fruit subglobose, 6–9 mm. thick, dull green or becoming slightly red late in the season, with a prominent slightly elevated calyx, thin dry flesh and usually 3 nutlets.

Thickets and dry rocky ground. Southern Ohio and southeastern Kentucky. Ohio: Gallipolis, Gallia County. R. E. Horsey, No. 2247, May 13, 1925 (type); September 20, 1925, May 19, 1926; No. 2251, same locality, May 13, 1925, September 20, 1925, May 19, 1926. Kentucky: Middlesboro, Bell County, R. E. Horsey, No. 1973, May 27, 1924, Oct. 2, 1924, May 26, 1926; No. 1975, same locality, May 27, 1924, October 2, 1924, May 26, 1926. All specimens in the Herbarium of the Arnold Arboretum, Jamaica Plain, Massachusetts.

Crataegus Horseyi, of the Intricatae series, is perhaps most nearly related to *Crataegus rubella* Beadle. But it differs from that species in its slightly smaller leaves with more slender petioles, its more compact inflorescence of smaller flowers with usually 5 stamens, and in the globose fruit which is dull green or only slightly reddened, instead of being bright red or orange, and with regularly 3 nutlets. It should be looked for at intermediate or other stations in the region where it has been found. Thanks are due to my daughter, Grace Palmer, for the figure that accompanies the description.

25. Crataegus biltmoreana Beadle (*C. polybracteata* Ashe, *C. modesta* Sarg., *C. intricata* of Egglest., not Lange)
Fairfield, Greene, Tuscarawas.

SERIES VII. ROTUNDIFOLIAE

26. Crataegus Margaretta Ashe
a. var. Margaretta
Adams, Auglaize, Brown, Butler, Champaign, Clark, Defiance, Franklin, Gallia, Hamilton, Hardin, Highland, Jackson, Lucas, Meigs, Montgomery, Preble, Union, Washington, Williams.
forma xanthocarpa Sarg.
Defiance.
b. var. Brownei (Britt.) Sarg. (*C. Brownei* Britt.)
Franklin, Union, Washington, Williams.
c. var. meiophylla (Sarg.) Palmer (*C. meiophylla* Sarg.)
Adams, Butler, Defiance, Hardin.

27. Crataegus sicca Sarg. var. **glabrifolia** (Sarg.) Palmer, stat. nov. (*C. glabrifolia* Sarg.)
Cuyahoga, Defiance, Lawrence.

SERIES VIII. BRAINERDIANAE

28. Crataegus Brainerdi Sarg.
a. var. Brainerdi
Lucas, Richland.
b. var. scabrida (Sarg.) Egglest. (*C. scabrida* Sarg.)
Richland.
29. Crataegus Coleae Sarg. (*C. incerta* Sarg.)
Auglaize, Mahoning.

SERIES IX. TENUIFOLIAE

30. Crataegus macrosperma Ashe
a. var. macrosperma (*C. bella* Sarg., *C. colorata* Sarg., *C. cyanophylla* Sarg., *C. ignea* Sarg., *C. mineata* Ashe, *C. otiosa* Ashe, *C. prona* Ashe, *C. rubicunda* Sarg., *C. suavis* Sarg., *C. tenera* Ashe)
Ashland, Ashtabula, Auglaize, Carroll, Clinton, Columbiana, Cuyahoga, Defiance, Erie, Fairfield, Franklin, Gallia, Geauga, Lake, Lawrence, Licking, Logan, Lorain, Lucas, Medina, Muskingum, Portage, Putnam, Richland, Stark, Summit, Union, Vinton, Warren, Williams.
b. var. acutiloba (Sarg.) Egglest. (*C. acutiloba* Sarg.)
Franklin, Jefferson, Williams.
c. var. demissa (Sarg.) Egglest. (*C. demissa* Sarg., *C. sextilis* Sarg.)
Logan, Lorain, Trumbull.
d. var. matura (Sarg.) Egglest. (*C. matura* Sarg., *C. acuminata* Sarg.)
Franklin, Ottawa.
e. var. pentandra (Sarg.) Egglest. (*C. pentandra* Sarg., *C. exigua* Ashe)
Lorain, Richland, Trumbull, Vinton.
f. var. roanensis (Ashe) Palmer (*C. roanensis* Ashe)
Adams, Clinton, Fairfield, Highland, Lake, Licking, Lorain, Lucas, Muskingum, Ottawa, Richland, Scioto, Vinton.
31. Crataegus basilica Beadle (*C. taetrica* Sarg.)
Richland.
32. Crataegus lucorum Sarg. (*C. decens* Ashe)
Franklin, Richland, Vinton.

SERIES X. SILVICOLAE

33. Crataegus iracunda Beadle, var. silvicola (Beadle) Palmer (*C. silvicola* Beadle, *C. drymophila* Sarg.)
Washington.
34. Crataegus beata Sarg. (*C. opulens* Sarg.)
Holmes, Jackson, Lucas, Morrow, Union.
35. Crataegus brumalis Sarg.
Ashtabula, Geauga, Lake, Tuscarawas.
36. Crataegus gravis Ashe (*C. remota* Sarg.)
Ashtabula, Franklin, Hardin, Jefferson, Lake, Mahoning, Ottawa, Trumbull.
37. Crataegus populnea Ashe (*C. blairensis* Sarg., *C. marcida* Ashe, *C. propinqua* Ashe)
Ashtabula, Erie, Franklin, Lake, Lorain, Richland, Trumbull, Tuscarawas.
38. Crataegus stolonifera Sarg.
Lorain, Portage.

SERIES XI. PRUINOSAE

39. Crataegus pruinosa (Wendl.) K. Koch
    a. var. pruinosa (*C. amoena* Sarg., *C. ater* Ashe, *C. horridula* Sarg., *C. Howeana* Sarg., *C. siliens* Ashe)
    Ashtabula, Athens, Brown, Butler, Clermont, Erie, Franklin, Gallia, Guernsey, Hamilton, Harrison, Highland, Hocking, Jackson, Jefferson, Lake, Lawrence, Logan, Lorain, Mahoning, Morgan, Muskingum, Ottawa, Pickaway, Preble, Putnam, Richland, Sandusky, Seneca, Trumbull, Tuscarawas, Vinton, Washington, Wood.
    forma angulata (Sarg.) Palmer (*C. angulata* Sarg., *C. placiva* Sarg.)
    Jackson, Washington.
    b. var. dissona (Sarg.) Egglest. (*C. dissona* Sarg., *C. marriettensis* Sarg., *C. relicta* Sarg.)
    Butler, Defiance, Hardin, Lake, Lawrence, Lorain, Richland, Scioto, Tuscarawas, Washington.
    c. var. brachypoda (Sarg.) Palmer (*C. brachypoda* Sarg.) Clermont, Meigs.
    d. var. latisepala (Ashe) Egglest. (*C. latisepala* Ashe, *C. cognata* Sarg., *C. conjuncta* Sarg., *C. jejuna* Sarg.)
    Franklin, Gallia, Jefferson, Lake, Mahoning, Meigs, Ottawa, Perry, Richland, Vinton, Washington.

40. Crataegus compacta Sarg. (*C. ellipticifolia* Sarg., *C. repentina* Sarg.)
    Brown, Delaware, Franklin, Jackson, Lake, Ross.

41. Crataegus Crawfordiana Sarg.
    Union.

42. Crataegus disjuncta Sarg.
    Mahoning.

43. Crataegus formosa Sarg.
    Wood.

44. Crataegus franklinensis Sarg.
    Erie, Franklin, Lawrence.

45. Crataegus gaudens Sarg.
    Lake, Perry.

46. Crataegus Gattingeri Ashe (*C. bedfordensis* Sarg.)
    Cuyahoga, Franklin, Jefferson, Lawrence, Logan, Lorain, Meigs, Preble, Scioto, Warren, Washington.

47. Crataegus Jessupi Sarg. (*C. divisifolia* Sarg.)
    Ashland, Franklin, Ottawa.

48. Crataegus leiophylla Sarg. (*C. gracilis* Sarg., *C. longipedunculata* Sarg.)
    Harrison, Jefferson, Lorain, Muskingum.

49. Crataegus locuples Sarg.
    Clermont, Coshocton, Franklin, Gallia, Highland, Lake.

50. Crataegus Mackenzii Sarg., var. bracteata (Sarg.) Palmer (*C. bracteata* Sarg.)
    Delaware, Franklin, Meigs.

51. Crataegus Milleri Sarg.
    Astabula, Lake.

52. Crataegus Porteri Britt.
    Ashtabula, Lake, Muskingum, Portage.

53. Crataegus rugosa Ashe (*C. onusta* Ashe)
    Adams, Brown, Carroll, Hamilton, Lawrence, Licking, Lorain, Richland, Tuscarawas, Warren, Washington.

54. Crataegus virella Ashe
    Richland.

SERIES XII. COCCINEAE

55. Crataegus pedicellata Sarg.
    a. var. pedicellata (*C. sejuncta* Sarg.)
       Ashtabula, Auglaize, Clermont, Crawford, Cuyahoga, Fairfield, Franklin, Hamilton, Hardin, Henry, Huron, Jefferson, Lake, Lorain, Ottawa, Putnam, Richland, Trumbull, Vinton, Washington, Wood.
    b. var. **assurgens** (Sarg.) Palmer, stat. nov. (*C. assurgens* Sarg.)
       Ashtabula, Coshocton, Cuyahoga, Geauga, Lake, Lucas, Ottawa, Trumbull, Wood.
    c. var. Robesoniana (Sarg.) Palmer (*C. Robesoniana* Sarg.)
       Lake, Richland.
    d. var. albicans (Ashe) Palmer (*C. albicans* Ashe, *C. cristata* Ashe)
       Ashtabula, Belmont, Brown, Franklin, Hocking, Huron, Jefferson, Knox, Lake, Licking, Lorain, Lucas, Morgan, Richland, Ross.
56. Crataegus Holmesiana Ashe
    a. var. Holmesiana
       Cuyahoga, Lorain, Monroe.
    b. var. amicta (Sarg.) Palmer (*C. amicta* Sarg., *C. elongata* Sarg.)
       Richland.
57. Crataegus Habereri Sarg.
       Jefferson, Lake, Lorain.
58. Crataegus Hillii Sarg.
       Lake, Paulding, Richland.
59. Crataegus pennsylvanica Ashe
       Clinton, Cuyahoga, Franklin.
60. Crataegus Pringlei Sarg.
       Jackson, Lake, Ottawa, Richland, Shelby, Williams.
61. Crataegus Putnamiana Sarg.
       Brown, Franklin, Gallia, Lawrence, Licking, Meigs, Washington, Wood.

SERIES XIII. MOLLES

62. Crataegus mollis (T. & G.) Scheele
    a. var. mollis (*C. redolens* Ashe)
       Auglaize, Belmont, Brown, Butler, Clark, Clermont, Clinton, Darke, Defiance, Delaware, Erie, Franklin, Fulton, Hamilton, Hancock, Hardin, Henry, Highland, Lake, Logan, Lorain, Lucas, Madison, Monroe, Montgomery, Morrow, Ottawa, Paulding, Pickaway, Richland, Sandusky, Seneca, Shelby, Union, Warren, Wayne, Williams, Wood, Wyandot.
    b. var. sera (Sarg.) Egglest. (*C. sera* Sarg., *C. mollipes* Sarg.)
       Lake.
63. Crataegus submollis Sarg.
       Lake.

SERIES XIV. MACRACANTHAE

64. Crataegus succulenta Link.
    a. var. succulenta (*C. gemmosa* Sarg., *C. rutila* Sarg.)
       Auglaize, Belmont, Butler, Carroll, Clermont, Fairfield, Franklin, Highland, Hocking, Knox, Lake, Lorain, Lucas, Medina, Ottawa, Portage, Richland, Ross, Shelby, Summit, Union, Wayne, Wood.
    b. var. macracantha (Lodd.) Egglest. (*C. macracantha* Lodd.)
       Franklin, Ottawa, Vinton.
    c. var. michiganensis (Ashe) Palmer (*C. michiganensis* Ashe)
       Wayne.
    d. var. neofluvialis (Ashe) Palmer (*C. neofluvialis* Ashe, *C. tanuphylla* Sarg.)
       Richland.

e. var. pertomentosa (Ashe) Palmer (*C. pertomentosa* Ashe)
Auglaize, Butler, Richland.

65. Crataegus Calpodendron (Ehrh.) Medic.
a. var. Calpodendron (*C. pubifolia* Ashe, *C. structilis* Ashe, *C. tomentosa* of many auth.)
Athens, Auglaize, Butler, Clermont, Clinton, Defiance, Erie, Fairfield, Franklin, Hamilton, Hardin, Lake, Lawrence, Licking, Logan, Lorain, Lucas, Meigs, Montgomery, Ottawa, Perry, Portage, Putnam, Sandusky, Scioto, Stark, Trumbull, Washington, Wayne, Wood.
b. var. globosa (Sarg.) Palmer (*C. globosa* Sarg.)
Preble, Wood.
c. var. microcarpa (Chapm.) Palmer (*C. tomentosa* var. *microcarpa* Chapm., *C. tomentosa* var. *Chapmani* Beadle, *C. Chapmani* Ashe)
Gallia.

66. Crataegus laetifica Sarg.
Defiance, Geauga, Lake, Richland.

67. Crataegus prunifolia (Poir.) Pers.
Lake. (an escape)

HYBRIDS

Crataegus Calpodendron x crus-galli
Lake, Trumbull.
Crataegus crus-galli x succulenta var. macracantha?
Defiance.
Crataegus Margaretta x mollis
Preble.
Crataegus mollis x pedicellata?
Clermont.

It is suspected that several others that have been described as species are of hybrid origin. But in the absence of positive evidence, they are treated under the published names.

The Mathematics of Physics and Chemistry. *Henry Margenau* and *George Moseley Murphy*. D. Van Nostrand Company, Inc., Princeton, New Jersey. Second Edition, 1956. xii+604 pp. $6.85.

This excellent book can serve many useful purposes. It could serve as a text in various courses in applied mathematics at either the senior or first year graduate level. It could also be used as a text in introductory courses in fields such as quantum mechanics or statistical mechanics. As a reference book it should prove handy to the physicist or chemist who needs an occasional reminder of certain mathematical concepts and to the teacher of mathematics who may need a source of applications.

Although the part dealing with numerical analysis has been expanded it seems unfortunate that the authors could not have found room for a brief discussion of high speed machine computation.

The chapter heading and lengths are: Mathematics of Thermodynamics (31), Ordinary Differential Equations (57), Special Functions (48), Vector Analysis (35), Coordinate Systems, Vectors and Curvilinear Coordinates (26), Calculus of Variations (18), Partial Differential Equations of Classical Physics (30), Eigenvalues and Eigenfunctions (36), Mechanics of Molecules (20), Matrices and Matrix Algebra (31), Quantum Mechanics (98), Statistical Mechanics (36), Numerical Calculations (53), Linear Integral Equations (35), Group Theory (39).

D. Ranson Whitney.

A PRELIMINARY SURVEY OF THE CRANE-FLIES OF DELAWARE COUNTY, OHIO
(DIPTERA: TIPULOIDEA)

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Although several collections of Tipuloidea have been made in the states surrounding Ohio, no record dealing specifically with the Ohio fauna has been published. In a preliminary survey of the crane-fly fauna of "Neotoma", a wooded valley in Hocking County, Ohio, the late Dr. J. Speed Rogers collected many species, but his recent death interrupted that study before the list could be organized and published. The crane-fly fauna of Michigan is relatively well known thanks to the diligent and painstaking collecting efforts of Dr. Rogers and his students. His paper on the crane-flies of the George Reserve in southern Michigan lists 206 species (Rogers, 1942). Dickinson (1932) discusses 137 species occurring in the state of Wisconsin. Since the present paper covers the results of only three years collecting restricted to the spring and fall months the list of 153 species compares favorably with other local lists. Most of the specimens collected are on deposit in the Museum of Zoology, University of Michigan. A few of the more interesting specimens have been retained in the author's collection.

GENERAL FEATURES OF DELAWARE COUNTY

Delaware County is located in nearly the geographical center of Ohio. It is covered by the Delaware, Marengo, Dublin and Westerville topographic sheets. Excluding the stream valleys the county is a nearly level plain lying about 850 ft. above sea level. This upland plain obtains its only relief in the form of broad belts of gently rolling glacial moraines. The county lies within the drainage of the Scioto River and its three main tributaries. The larger streams all flow in a southerly direction with their beds lying either on the thick deposits of glacial till or on the underlying bedrock. The valley floors are from 20 to 140 ft. below the adjacent uplands and form a major feature of the relief. The county lies well within the till plain region of the Central Lowland Province and is covered with a mantle of varying thickness of glacial drift dropped by the Wisconsin ice sheet. The bedrock is locally exposed along the larger streams and may even form rather impressive cliffs. It is marine in origin and composed of nearly level strata of shales and limestones. The beds have a slight dip to the southeast and outcrop in bands across the county.

COLLECTING STATIONS

During the course of the study several favorite collecting sites within the county were visited repeatedly. An attempt was made to include as much diversity of habitats as possible. The six stations are briefly characterized below. (fig. 1).

Beggar Louse Hill (B.L.H.) is a rather extensive wooded area located along the south shore of Alum Creek approximately eight miles northeast of the city of Delaware. The land situated along the river is poorly drained and supports a floodplain forest of an elm-ash-soft maple association with admixtures of sycamore, willow and poplar. The north-facing valley wall is heavily wooded with sugar maple being the most abundant tree species. The wall is dissected by several deeply shaded ravines leading back into the adjacent highlands. The

upland till plain extending south from the river bluffs is partially pastured by cattle and is generally flat and poorly drained. A mosaic of plant associations is present according to the drainage conditions. The poorly drained depressions are covered with swamp forest communities while beech-maple and even oak-hickory associations occur on the slightly higher, better drained sites. A spring-fed, sluggish stream meanders across this upland area and a grass-sedge and cat-tail marsh has developed along its course. The herbaceous plants are not very abundant due to extensive grazing by livestock.

Case Farm Woods (C.F.W.) is a floodplain and valley wall woods located along the east shore of the Olentangy River three miles north of Delaware. The rather narrow floodplain is a mixture of an old field habitat and second growth swamp forest. Elm, willow, red maple and poplar are the commonest tree species. The vernal herbaceous flora is very well developed and is replaced as summer advances by dense growths of rank-growing composites. The valley wall is rather heavily wooded and is dissected by a few small, deeply shaded ravines.

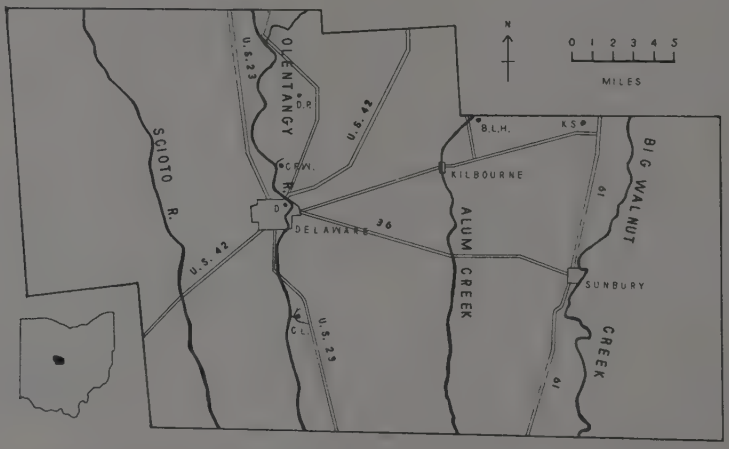

FIGURE 1. Map of Delaware County, Ohio showing location of collecting stations. B. L.H.—Beggar Louse Hill, C.F.W.—Case Farm Woods, C.L.—Camp Lazarus, D.—Delaware, D.P.—Dike Pond, K.S.—Kilbourne Swamp.

Camp Lazarus (C.L.) is a heavily wooded tract of land contained within the boundaries of a Boy Scout Reservation situated five miles south of Delaware between U.S. Route 23 and the Olentangy River. Three types of forest communities cover most of the area depending upon the drainage. Various phases of swamp forest occupy all of the stream valleys and much of the more poorly drained uplands. Beech-maple occurs regularly on the moderately drained uplands and north-facing slopes while oak-hickory is present on the dry bluffs and south-facing slopes. Many wooded ravines cut back into the surrounding uplands. These are moist throughout the year, but contain flowing water only during spring and early summer. All are heavily wooded. Rather high, moist cliffs of shale are exposed along the main west flowing stream and its largest tributary and a small outcrop of limestone is located along the main stream near its confluence with the Olentangy River.

Delaware (D.) is a city of about 11,000 population within which considerable collecting was done along the west shore of the Olentangy River. The stream is narrowly bordered with swamp forest tree species with willows, elm, cottonwood and red maple being the most abundant. At low water stage the river bottom supports dense growths of water willow (*Dianthera americana* L.). The land extending back from the river is generally flat and cultivated or pastured and is a relatively poor habitat for crane-flies. Some light trapping was done near the river in north Delaware.

Dike Pond (D.P.) is a relatively new marsh formed by the damming of a small stream by a dike of the Delaware Dam five miles north of Delaware and about one mile east of the Olentangy River. The central portion of the marsh is covered by a nearly pure stand of cat-tail and a grass-sedge community is well developed around the edges. Dense growths of young willow have invaded the western margin of the area and the whole marsh seems to be rapidily going over to a shrubby swamp stage. Standing water is present only during the spring and early summer.

Kilbourne Swamp (K.S.) is an excellent example of the once extensive upland swamps that were formerly abundant on the flat, poorly drained till plains of central Ohio. The swamp is located approximately twelve miles northeast of Delaware. Water up to a foot in depth covers most of the area during spring and early summer and the substrate is noticeably wet throughout the year. Many rotting logs and stumps litter the floor of the elm-ash-soft maple forest.

CRANE-FLY HABITATS

Throughout the course of the study an attempt was made to correlate crane-fly distribution with the various complexes of plant associations, drainage and topography existing with the county. Field notes on the exact localities of captures were made and information was obtained on the plant associations present in the area along with data on the various physical features of the environment. Since the distribution of the adult flies gives only an approximation of the larval habitat, larvae were taken and rearing data were obtained whenever possible. Preliminary survey seems to indicate the presence of at least eight general crane-fly habitats in the county. These are briefly discussed below.

Beech-Maple Forests

Remmants of this originally extensive climax association are found on well drained sites along the north-facing slopes of the larger streams and on the flat to gently rolling upland till plains. The shrub layer is well developed and fairly rich in species with saplings of sugar maple being the most abundant. The herb stratum is luxuriant only during the spring and early summer, becoming inconspicuous as the tree canopy closes. Fallen logs and partially decayed stumps litter the forest floor and thick accumulations of leaf litter are present. Many species of the crane-fly genus *Tipula* have their larval stages in the moist, friable, well aerated soil beneath the protecting mat of decaying leaves. Other species develop in the many logs and stumps or in the cushions of moss covering them.

Floodplain Swamp Forests

Floodplains along the larger streams support a swamp forest dominated by red maple, white ash and American elm. Deep shade and high humidity combine to make this forest type one of the richest habitats for species of crane-flies in the county. The shrub layer is poorly developed except where the tree canopy has been broken admitting light to the forest floor. The herb layer is also sparsely

developed during the summer, although the vernal flora is very luxuriant and rich in species. During late summer various species of shade-tolerant composites may grow so profusely as to make passage difficult. The continually moist to wet soil is the preferred habitat for the larvae of many species of crane-flies, especially of the genera *Tipula* and *Nephrotoma.*

Upland Swamp Forests

Scattered throughout the county on the flat, poorly drained till plains are areas of densely wooded swamps. The dominant tree species seem to be red maple and American elm with lesser numbers of white ash and swamp white oak. Water collects in shallow depressions, forming vernal pools of varying extent up to a foot or more in depth. Although these pools gradually decrease in extent and depth as summer advances and all open water usually disappears by mid-July, the substrate remains moist throughout the year. The central portion of the swamp floor is an open expanse of decaying leaf litter overlying a black, mucky soil. Many fallen limbs and branches are scattered over the ground and these may be thickly covered by cushions of moss. The drier margins of the vernal pools have well developed shrub and herb layers which provide shelter for the adults of many crane-flies having their larval stages in the wet soil of the swamp.

Oak-Hickory Forests

Oak-hickory is a successional stage that develops on the dry, overly drained bluffs and on south-facing slopes along the larger streams. As the result of intense radiation and excessive evaporation, the soil is dry and unsuitable for most crane-fly larvae. The undergrowth is generally open with little development of a shrub layer. Fallen trees and decaying limbs may be abundant, but are usually too dry for most crane-fly larvae. The herb layer is composed mostly of xeric grasses and sedges along with several species of composites. The ground surface is frequently covered with a dry crust of lichens and mosses. Only a few species of crane-flies were regularly taken in this habitat.

Grass-Sedge Marshes

Small areas of herbaceous marsh dominated by various species of grasses and sedges are found in open areas on very poorly drained soil. Standing water may be present during spring and early summer and the substrate is permanently moist. The dense expanses of grass and sedge clumps form an excellent habitat for several species of marsh-loving crane-flies. Many larvae are found in the wet mud and silt of the marsh area.

Cat-tail Marshes

Only scattered fragments of this marsh type are found in the county on poorly drained soil along sluggish streams. Once it invades an area cat-tail may form nearly pure stands of considerable extent. Locally, this type of marsh is less productive of large numbers of crane-flies than are the more abundant grass-sedge marshes. Many species may enter the cat-tail for shelter as adults, but have their larval stages elsewhere.

Wet, Shaded Cliffs

Along the larger streams are occasional exposures of the underlying bedrock; shales in the eastern half of county, limestones in the western part. Frequently the water table is intersected along these exposures and a more or less continual trickle of water flows over the rock surfaces. Various species of lichens, liverworts and mosses become established on the moist substrate and provide food and shelter for the larvae of several small species of crane-flies.

Rivers and Streams

This habitat includes all actively flowing water confined within a definite channel as opposed to marshy areas where flowing water is absent or of an intermittent nature. The shallow water of the larger streams supports dense stands of water willow that seems to be the preferred habitat of a few species of crane-flies. Larvae of many other species are found in the stream beneath accumulations of leaf litter, under rocks, in mats of algae or in the silt and mud of the stream bed.

ANNOTATED LIST

For each species in the annotated list a very brief summary of its abundance and habitat distribution is given along with the months and stations (abbreviated) in which adults were collected. Notes on biology, immature stages, distribution and taxonomic placement are added for certain species. The systematic position of families and genera follows closely the arrangement presented by Alexander in his very useful manual on the crane-flies of Connecticut (Alexander, 1942).

PTYCHOPTERIDAE

1. *Ptychoptera rufocincta* O.S.

Restricted to, but uncommon in, shaded grass-sedge marshes. Late May, early June. B.L.H.

2. *Bittacomorpha clavipes* (Fabr.)

Fairly common in shaded marshes and along sluggish streams. May, August, B.L.H., C.L.

TRICHOCERIDAE

3. *Trichocera fernaldi* Alex.

Common to abundant in woodlands during warm fall and winter days. October, November, December. B.L.H., C.L. Mating swarms over rotting logs and stumps.

4. *Trichocera garreti* Alex.

Uncommon in moist woodlands during warm fall and winter days. November, December. C.L.

5. *Trichocera saltator* (Harris)

Common to very abundant in woodlands, open fields and around piles of decaying organic matter. September, October, November, December, January. B.L.H., C.L., C.F.W.

ANISOPODIDAE

6. *Anisopus alternatus* (Say)

1 ♂ from shaded ravine of small woodland stream. April 8, 1952. C.F.W.

7. *Anisopus marginatus* (Say)

Common to occasionally abundant in moist, deeply shaded ravines. Late April, early May. C.F.W., C.L.

TIPULIDAE

8. *Dolichopeza* (*Dolichopeza*) *americana* Needham

3 ♂♂, 1 ♀ from moist, shaded ravines. Late May. C.L.

9. *Dolichopeza* (*Oropeza*) *carolus* Alex.

Fairly common in moist woodland ravines and on wet cliff faces. Late June. B.L.H., C.L.

10. *Dolichopeza* (*O.*) *polita* (Johnson)

1 ♂ from small woodland ravine. June 14, 1951. C.F.W.

11. *Dolichopeza* (*O.*) *sayi* (Johnson)

2 ♂♂ from moist upland woods. June 13, 1955. B.L.H.

12. *Dolichopeza* (*O.*) *tridenticulata* Alex.

Common to locally abundant in moist woodland ravines and around rotting logs and stumps. Late May, early June. C.F.W., C.L. Larvae taken February 9, 1952 from thin carpet of moss covering sodden, well-decayed elm logs lying on forest floor at Kilbourne Swamp. Adults emerged March 8 to 16.

13. *Dolichopeza* (*O.*) *walleyi* (Alex.)

1 ♂ from moist ravine. June 14, 1951. B.L.H.

14. *Ctenophora nubecula* (O.S.)

1 ♂ reared from larva taken on February 25, 1951 in fallen willow branch along Olentangy River in Delaware. Emergence on April 8.

15. *Prioncera fuscipennis* (Loew)

Fairly common in grass-sedge and cat-tail marshes. Late May. D.

16. *Nephrotoma eucera* (Loew)

2 ♂♂ from margin of wooded swamp. June 15, 1951. K.S.

17. *Neophrotoma euceroides* Alex.

Common to abundant in wet woodlands; less abundant along marshy streams. April, May. B.L.H., C.L.

18. *Nephrotoma ferruginea* (Fabr.)

Common to abundant in open woodlands, along rivers and in wet pastures; less common in drier situations. May, June, October. B.L.H., C.L., D., D.P. Many light trap records on warm, humid nights.

19. *Nephrotoma incurva* (Loew)

1 ♂ from grass-sedge marsh. June 13, 1951. D.

20. *Nephrotoma macrocera* (Say)

2 ♂♂ from shaded shores of Olentangy River. May 29, August 15, 1951. D.

21. *Nephrotoma polymera* (Loew)

2 ♂♂ from floodplain forest. Late May. C.L.

22. *Nephrotoma virescens* (Loew)

1 ♂, 1 ♀ from moist to wet upland elm-ash-maple forest. June, September, 1950. C.L.

23. *Tipula* (*Trichotipula*) *oropezoides* Johnson

Fairly common around shaded hillside seepage areas; less common in floodplain woods. Late May. B.L.H., C.L.

24. *Tipula* (*T.*) *unifasciata* (Loew)

2 ♂♂ from margins of small woodland stream. September 4, 1950. C.L.

25. *Tipula* (*Nobilotipula*) *collaris* Say

Fairly common around grassy hillside seepage areas. Late April, early May. B.L.H.

26. *Tipula* (*Nippotipula*) *abdominalis* (Say)

1 ♂ (dead) in spider web beneath culvert over a small stream. October 4, 1950. C.L. Larvae abundant in leaf-filled streams of Camp Lazarus.

27. *Tipula* (*Vestiplex*) *longiventris* Loew

Fairly common in beech-maple forests; rare to absent in other forest types. Early June. B.L.H., C.L.

28. *Tipula* (*Yamatotipula*) *caloptera* Loew

Common along rivers and larger streams; rare to absent along small brooks. May, September. C.F.W., C.L., D.

29. *Tipula* (*Y.*) *concava* Alex.

Common to abundant along rivers and streams of all sizes; rare in marshes. May, June, August, September. B.L.H., C.F.W., C.L., D.

30. *Tipula* (*Y.*) *dejecta* Walker

Abundant in open grass-sedge marshes and along sluggish streams; absent in heavily shaded swamps. Late April, early May. B.L.H., C.F.W., C.L., D., D.P.

31. *Tipula* (*Y.*) *furca* Walker

Common, occasionally abundant, along rivers and streams; less numerous in grass-sedge marshes; absent in wooded swamps. May, September. B.L.H., C.F.W., C.L., D., D.P.

32. *Tipula* (*Y.*) *jacobus* Alex.
1 ♂ from margin of heavily wooded swamp. June 15, 1951. K.S.

33. *Tipula* (*Y.*) *noveboracensis* Alex.
Few specimens from grassy margins of streams. Early to mid-May. B.L.H., C.L. Known range hereby extended about 100 miles southwestward from previous records in New England, New York, Michigan and eastern Canada. Adults later reared from larvae collected December 10, 1954 in small creek near Ithaca, New York. Adults emerged February 11, 1955.

34. *Tipula* (*Y.*) *sayi* Alex.
Common on grassy shores of rivers and streams. Late August, early September. B.L.H., C.L., D.

35. *Tipula* (*Y.*) *strepens* Loew
Fairly common in spring-fed grass-sedge marshes. Late May. B.L.H.

36. *Tipula* (*Y.*) *tephrocephala* Loew
1 ♂ from pastured, wet upland woods. June 4, 1950. B.L.H.

37. *Tipula* (*Y.*) *tricolor* Fabr.
Abundant in grass-sedge marshes; common along marshy streams and in open swamp woods. Late May. B.L.H., D. P.

38. *Tipula* (*Tipula*) *cunctans* Say
Abundant along marshy woodland streams; common in open grass-sedge marshes; rare to absent in drier situations. October. B.L.H., C.F.W., C.L., D.P.

39. *Tipula* (*T.*) *ultima* Alex.
Abundant in wet to mesic woodlands; common in grass-sedge marshes and along rivers; rare in dry woods. September, October. B.L.H., C.F.W., C.L., D.P.

40. *Tipula* (*Oreomyza*) *borealis* Walker
Common to locally abundant in open elm-ash-maple woods; rare to absent in better drained woodlands. Early September. B.L.H., C.L.

41. *Tipula* (*O.*) *fragilis* Loew
Fairly common in floodplain woods; less numerous in beech-maple forests; rare to absent in drier woodlands. Early October. B.L.H., C.L. Adults typically found flying up and down tree trunks a few inches from the bark.

42. *Tipula* (*O.*) *ignobilis* Loew
Few specimens from vicinity of limestone outcrop bordering small woodland stream. June 7, 1952. C.L.

43. *Tipula* (*O.*) *entomophthorae* Alex.
1 ♂ from elm-ash-maple floodplain woods. June 9, 1951. C.L.

44. *Tipula* (*O.*) *trivittata* Say
Few specimens from moist to mesic woodlands. May, early June. B.L.H., C.L. Larvae common under loose bark of well-decayed logs during winter and spring. Pupal period lasts eight to ten days.

45. *Tipula* (*Schummelia*) *hermannia* Alex.
Fairly common in beech-maple forest; less numerous in poorly drained elm-ash-maple woods; very rare to absent in dry woodlands. Late May, early June. B.L.H., C.L.

46. *Tipula* (*Lunatipula*) *bicornis* Forbes
Common to locally abundant in open grass-sedge marshes, poorly drained woods and along sluggish woodland streams; less numerous in densely wooded swamps; rare to absent in beech-maple and oak-hickory forests. May, early June. B.L.H., C.F.W., C.L., D., K. S.

47. *Tipula* (*L.*) *johnsoniana* Alex.
Several ♂♂ from elm-ash-maple floodplain woods. Late June. C.L.

48. *Tipula* (*L.*) *morrisoni* Alex.
Fairly common in wet upland woods. June. B.L.H.

49. *Tipula* (*L.*) *dorsimacula* Walker
1 ♂ from moist floodplain woods. April 27, 1951. C.L.

50. *Tipula* (*L.*) *duplex* Walker
1 ♀ from wet, upland pastured woods. September 1, 1950. B.L.H.

51. *Tipula* (*L.*) *flavoumbrosa* Alex.
Few specimens from elm-ash-maple floodplain woods. Early June. C.L.

52. *Tipula* (*L.*) *fuliginosa* (Say)
Common, occasionally abundant, within herb stratum of beech-maple forests; less numerous in both drier and wetter woodlands. Late May, early June. C.L.

53. *Tipula* (*L.*) *submaculata* Loew
Few ♂♂ from open floodplain woods. Late May, early June. B.L.H., C.L.

54. *Tipula* (*L.*) *submaculata-mallochi* intergrades
Common, occasionally abundant, in wet upland woods, less numerous in mesic forests. May, June. B.L.H., C.L. Hypogyial characters show that the Delaware County material is intermediate between the two recognized species.

55. *Tipula* (*L.*) *triplex* Walker
Common to locally abundant in wet elm-ash-maple woods; less numerous in open grass-sedge and cat-tail marshes. May, early June. B.L.H., C.L., D.P., K.S.

56. *Tipula* (*L.*) *triton Alex.*
1 ♂ near open grass-sedge-cat-tail marsh. May 25, 1952. B.L.H.

57. *Limonia* (*Limonia*) *fallax* (Johnson)
Uncommon and local along wooded margins of small streams. May, June. B.L.H., C.L., K.S.

58. *Limonia* (*L.*) *fusca* Meigen
1 ♂ from wet face of shaded shale cliff. May 29, 1951. C.L.

59. *Limonia* (*L.*) *indigena* O.S.
Uncommon and local in mesic woodlands. Early May. B.L.H., C.L. All specimens taken on trunks of standing trees.

60. *Limonia* (*L.*) *rara* (O.S.)
Several specimens taken from interior of hollow logs lying in floodplain woods. September, October. B.L.H., C.L. Few ♀♀ attracted to light.

61. *Limonia* (*L.*) *triocellata* (O.S.)
Typical of, but uncommon in, more open beech-maple forests. May, September, October. B.L.H., C.F.W., C.L.

62. *Limonia* (*L.*) *tristigma* (O.S.)
2 ♂♂ from margins of heavily wooded swamp. June 15, 1950, August 12, 1951. K.S.

63. *Limonia* (*Discobola*) *annulata* (Linn.)
Fairly common in hollow logs and in similar protected situations; ossasional on tree trunks in wet mesic woodlands. May, June, September, October. B.L.H., C.L.

64. *Limonia* (*Dicranomyia*) *divisa* Alex.
Common to abundant in variety of habitats as grass-sedge and cat-tail marshes, wet elm-ash-maple woods, and mesic beech-maple forests; especially numerous in shaded woodland ravines having moist to wet banks. April, May, August, September, October. B.L.H., C.F.W., C.L., D., D.P., K.S. Many light records for both sexes.

65. *Limonia* (*D.*) *gladiator* (O.S.)
Uncommon in wet woodlands and in grass-sedge marshes. September, October. B.L.H., C.L.

66. *Limonia* (*D.*) *haeretica* O.S.
Several light trap records on warm, humid nights. October. D.

67. *Limonia* (*D.*) *humidicola* (O.S.)
Abundant at limestone outcrop in Camp Lazarus; common, occasionally abundant, along wet to moist banks of woodland ravines. April, May, June, September, October. B.L.H., C.L. Larvae numerous in wet moss and liverwort mats growing on moist shale and limestone cliffs.

68. *Limonia* (*D.*) *immodesta* (O.S.)
Fairly common in poorly drained floodplain forests; occasional in moist, shaded ravines. October. B.L.H., C.L., K.S.

69. *Limonia* (*D.*) *iowensis* (Rogers)

Common in poorly drained floodplain woods having rich undergrowth; fairly common in grass-sedge and cat-tail marshes; less common in better drained woodlands. May, September, October. B.L.H., C.F.W., C.L., D., D.P.

70. *Limonia* (*D.*) *liberta* (O.S.)

Common in moist floodplain woods and around hillside seepage areas; rare to absent in mesic woodlands. Late April, May, June, September, October. B.L.H., C.F.W., C.L.

71. *Limonia* (*D.*) *longipennis* (Schummel)

Fairly common in open grass-sedge and cat-tail marshes. Mid-May. D.P. Several light trap records on warm, humid nights.

72. *Limonia* (*D.*) *pudica* (O.S.)

Fairly common in poorly drained woodlands; less numerous in open marshes, unshaded ravines and along streams. Mid-May, early June. B.L.H., C.L., D., D.,P.

73. *Limonia* (*D.*) *stulta* (O.S.)

Occasionally abundant on wet face of limestone outcrop in Camp Lazarus; not taken elsewhere. May, early June.

74. *Limonia* (*Rhipidia*) *domestica* (O.S.)

Common to abundant in wet floodplain woods; less numerous in beech-maple forests; rare in dry woodlands and in open marshes. May, June, September, October. B.L.H., C.F.W., C.L.

75. *Limonia* (*R.*) *fidelis* (O.S.)

Uncommon in moist and mesic woodlands having many fallen logs and stumps; rare to absent in drier situations. May, early June. B.L.H., C.L., K.S. Larvae taken November 15, 1951 from wet, decaying heartwood of standing beech trees. Adults emerged December 27. Larvae also found under loose bark of decaying elm logs and in moist, powdery material under bark of white oak stumps.

76. *Limonia* (*R.*) *maculata* (Meigen)

Uncommon in moist elm-ash-maple forests; very rare to absent elsewhere. Late May, October. B.L.H., C.L.

77. *Limonia* (*G.*) *canadensis* (Westwood)

Common, occasionally abundant, on wet shale and limestone cliffs and banks; rare elsewhere in moist woods. Late April, May, September, early October. B.L.H., C.F.W., C.L. Several specimens of both sexes taken on expanded flowers of white snake root (*Eupatorium album* L.)

78. *Limonia* (*G.*) *rostrata* (Say)

1 ♂ from open grass-sedge-cat-tail marsh. May 25, 1952. B.L.H.

79. *Helius flavipes* (*Macquart*)

Common, occasionally abundant, in unshaded grass-sedge and cat-tail marshes; less numerous in shaded marshy areas along sluggish streams; absent in wooded swamps. May, early June. B.L.H., D., D.P.

80. *Dicranoptycha megaphallus* Alex.

1 ♂ from margin of heavily wooded swamp. June 15, 1952. K.S.

81. *Dicranoptycha septemtrionis* Alex.

3 ♂♂ from beech-maple forest. October 9, 1952. C.L.

82. *Ula elegans* O.S.

1 ♂ from herb stratum of upland beech-maple forest. October 9, 1951. C.L.

83. *Pedicia* (*Pedicia*) *albivitta* Walker

Uncommon and apparently restricted to margins of rapidly flowing woodland streams. September, October. B.L.H., C.L.

84. *Pedicia* (*Tricyphona*) *inconstans* (O.S.)

Common to abundant in open grass-sedge marshes and along grassy margins of sluggish woodland streams; rare to absent in wooded swamps. May, September, October. B.L.H., C.L., D., D.P.

85. *Dicranota* (*Amalopina*) *flaveola* (O.S.)

Uncommon in moist, shaded woodland ravines; not taken elsewhere. Late September. B.L.H., C.L.

86. *Dicranota* (*Rhapidolabis*) *forceps* (Alex.)
Uncommon and apparently restricted to moist woodland ravines. May, September. B.L.H., C.L.
87. *Oxydiscus minutus* (Alex.)
Common to locally abundant on moist, shaded cliffs and banks along woodland ravines. Mid-May. B.L.H., C.L.
88. *Epiphragma fascipennis* (Say)
Common in floodplain woods and in wooded swamps; occasional in beech-maple forests. May. B.L.H., C.L., K.S.
89. *Epiphragma solatrix* (O.S.)
Fairly common in wooded swamps and in wet floodplain woods; less numerous to absent in drier woodlands. May, June, late August, September. B.L.H., C.L., K.S.
90. *Dactylolabis cubitalis* (O.S)
Locally very abundant in herb layer of floodplain woods; rare to absent in beech-maple and oak-hickory communities. Mid to late May. C.L.
91. *Dactylolabis hudsonica* Alex.
1 ♀ taken on wet face of limestone exposure. May 3, 1951. C.L.
92. *Dactylolabis montana* (O.S.)
Common, occasionally very abundant, around limestone outcrop in Camp Lazarus. Late April, May. Larvae and pupae collected in wet mosses and liverworts growing on outcrop.
93. *Prolimnophila areolata* (O.S.)
1 ♂ from floodplain woods bordering small stream. May 28, 1951. C.L.
94. *Austrolimnophila toxoneura* (O.S.)
Fairly common in wooded swamps and in moist floodplain woods; rare to absent in drier woodlands. Late May, early June. B.L.H., C.F.W., C.L., K.S.
95. *Psuedolimnophila contempta* (O.S.)
Common in moist floodplain woods and around shaded hillside seepage areas; uncommon in beech-maple forests; rare in oak-hickory woodlands. May, June, late August, September. B.L.H., C.L.
96. *Psuedolimnophila luteipennis* (O.S.)
Common in grass-sedge marshes and in more open swamps; less common in poorly drained floodplain woods; rare in beech-maple forests. May, early June, September, October. B.L.H., C.L., D.P., K.S.
97. *Limnophila* (*Lasiomastix*) *macrocera* (Say)
3 ♂♂, 1 ♀ from open grass-sedge marshes. Late May, early June. C.L., D.P.
98. *Limnophila* (*L.*) *subtenuicornis* (Alex.)
Uncommon along grassy margins of partially shaded, sluggish, woodland streams. Late April, May. B.L.H., C.L.
99. *Limnophila* (*Dicranophragma*) *fuscovaria* O.S.
Fairly common in wooded swamps and along sluggish woodland streams; rare elsewhere. May, June. B.L.H., C.L., K.S.
100. *Limnophila* (*Idiolimnophila*) *emmelina* Alex.
1 ♂ from moist woodland ravine. May 15, 1952. C.L.
101. *Limnophila* (*Prionolabis*) *rufibasis* O.S.
2 ♂♂ from grassy margins of sluggish stream in floodplain woods. May 12, 1952. C.L.
102. *Limnophila* (*P.*) *walleyi* Alex.
2 ♂♂, 1 ♀ from floodplain woods. May 13, 1951. B.L.H.
103. *Limnophila* (*Phylidorea*) *auripennis* Alex.
Few specimens from grassy margins of sluggish streams in floodplain and wet upland woods. Late May. B.L.H.
104. *Limnophila* (*P.*) *fratria* (O.S.)
1 ♂ from wet upland elm-ash-maple woods. May 6, 1951. B.L.H.
105. *Limnophila* (*P.*) *subcostata* (Alex.)
1 ♂ from wet floodplain woods. May 29, 1951. C.L.

106. *Limnophila* (*Limnophila*) *brevifurca* O.S.

Common in herb stratum of floodplain woods, especially near streams and around seepage areas; uncommon in partially shaded and open marshes. May. B.L.H., C.F.W., C.L.

107. *Limnophila* (*L.*) *niveitarsis* O.S.

Locally common in shaded ravines and in herb layer of moist elm-ash-maple woods. May, early June. C.L.

108. *Shannomyia lenta* (O.S.)

Common in moist floodplain woods; less numerous in upland elm-ash-maple and beech-maple forests; occasional in dry oak-hickory woodlands. May, June, September, October. B.L.H., C.L.

109. *Pilaria imbecilla* (O.S)

Occasional in floodplain woods. Late May, early June. B.L.H., C.L.

110. *Pilaria quadrata* (O.S.)

Occasional to fairly common in wet floodplain and upland woods; rare to absent in drier woodlands. May. B.L.H.

111. *Pilaria recondita* (O.S.)

1 ♂, 1 ♀ from floodplain woods. May 13, 1950, May 29, 1951. C.L.

112. *Pilaria tenuipes* (Say)

Frequently abundant along woodland streams; common in floodplain woods; infrequent to rare in mesic woodlands. May, June, August, September, October. B.L.H., C.F.W., C.L., K.S.

113. *Pilaria sp.*

2 ♂♂ from moist floodplain woods. May 15 and June 6, 1951. C.L. These specimens apparently differ from all described species.

114. *Ulomorpha pilosella* (O.S.)

3 ♂♂ from moist elm-ash-maple woods. Late May, early June. B.L.H., C.L.

115. *Hexatoma* (*Hexatoma*) *megacera* (O.S.)

Few specimens from rich vegetation bordering partially shaded woodland streams. Late April. C.F.W.

116. *Hexatoma* (*Eriocera*) *brachycera* (O.S.)

1 ♂ in spider web on vegetation along woodland stream. June 21, 1952. C.L.

117. *Hexatoma* (*E.*) *brevioricornis* Alex

2 ♀♀ reared from larvae collected in saturated soil bordering a small woodland pool at Camp Lazarus. Adults emerged May 15 and 18, 1952.

118. *Hexatoma* (*E.*) *fuliginosa* (O.S.)

5 ♂♂ from shaded margins of sluggish woodland streams. Late May. B.L.H.

119. *Hexatoma* (*E.*) *longicornis* (Walker)

Locally common along grassy margins of larger, fairly fast flowing streams, especially in wooded areas. Late April, May. B.L.H., C.F.W., C.L.

120. *Hexatoma* (*E.*) *wilsoni* (O.S.)

Locally abundant in open grass-sedge marshes; common along partially shaded sluggish streams; occasional around margins of wooded swamps. May, June. B.L.H., C.F.W., C.L., K.S. First Ohio record for this rather rare species.

121. *Elephantomyia westwoodi* O.S.

1 ♂, 1 ♀ from margins of dry, vernal ponds in upland woods. June 18, 1952. B.L.H.

122. *Cladura flavoferruginea* O.S.

Very abundant in elm-ash-maple and beech-maple forests; common in more mesic areas of oak-hickory woods; infrequent in drier woodlands. Late September, October. B.L.H., C.F.W., C.L., K.S.

123. *Neolimnophila ultima* (O.S.)

Common, occasionally abundant, in floodplain woods near seepage areas and along margins of sluggish streams; less numerous in beech-maple forests and in open marshes. Late April, September, October. B.L.H., C.L., D.P.

124. *Gnophomyia tristissima* O.S.

Locally numerous in moist floodplain woods; rare elsewhere in mesic to dry woodlands.

May, September. B.L.H., C.L. Many larvae collected from moist inner bark of recently fallen elm tree during April. Adults emerged one month later.

125. *Teucholabis immaculata* Alex.

2 ♂♂ from margin of upland swamp. May 15, June 6, 1951. K.S. Larvae collected in wet, powdery decayed heartwood of beech tree in Camp Lazarus on November 15, 1951. Adults emerged January 16 and 24, 1952.

126. *Gonomyia* (*Lipophleps*) *sulphurella* O.S.

Uncommon along grassy margins of small streams and rivers; rare in open marshes. Late May. C.L., D., D.P.

127. *Gonomyia* (*Gonomyia*) *currani* Alex.

1 ♂ from wooded margins of small stream. May 28, 1952. C.L.

128. *Gonomyia* (*G.*) *subcinerea* O.S.

Common in floodplain woods and in beech-maple forests having heavy undergrowth; especially numerous in moist ravines and along woodland streams. May, June, September, October. B.L.H., C.L., K.S.

129. *Erioptera* (*Gonempeda*) *nyctops* Alex.

2 ♂♂, 2 ♀♀ from moist, shaded ravines. May, early June. C.L.

130. *Erioptera* (*Symplecta*) *cana* (Walker)

Common and widespread; numerous records from open marshes, floodplain woods, wooded swamps and moist ravines; less abundant in drier woodlands. Late March, April, May, September. B.L.H., C.F.W., C.L., D.P., K.S.

131. *Erioptera* (*E.*) *chlorophylloides* Alex.

1 ♂ from partially shaded grass-sedge marsh. June 8, 1952. B.L.H.

132. *Erioptera* (*E.*) *septemtrionis* O.S.

Fairly common in floodplain woods and in moist, shaded ravines; occasional in grass-sedge marshes. May, October. B.L.H., C.L., D.

133. *Erioptera* (*E.*) *straminea* O.S.

Rare and local in partially shaded grass-sedge marshes. June. B.L.H.

134. *Erioptera* (*E.*) *vespertina* O.S.

1 ♂, 1 ♀ from open grass-sedge seepage area. Late May. D.

135. *Erioptera* (*Mesocyphona*) *caloptera* Say

Common and widespread; abundant in floodplain woods, moist ravines and along woodland streams; common in both open and shaded marshes and in wooded swamps; less numerous in beech-maple forests; rare in oak-hickory woodlands. May, June, August, September. B.L.H., C.F.W., C.L., D., D.P., K.S.

136. *Erioptera* (*M.*) *needhami* Alex.

1 ♂ from shaded grass-sedge marsh. June 19, 1952. B.L.H.

137. *Erioptera* (*M.*) *parva* O.S.

Few specimens from open grass-sedge marshes. Late May. D., D.P.

138. *Erioptera* (*Hoplolabis*) *armata* O.S.

Fairly common along woodland streams and in moist, shaded ravines. April, May. B.L.H., C.F.W., C.L.

139. *Erioptera* (*Ilisia*) *venusta* O.S.

Common in grass-sedge marshes and along sluggish streams; less numerous in drier woodlands. May. B.L.H., C.L., D., D.P.

140. *Ormosia bilineata* Dietz

Common, occasionally abundant, in moist, shaded ravines and on wet faces of shale cliffs and banks. Late April, May. B.L.H., C.L.

141. *Ormosia carolinensis* Alex.

Typical of, and frequently abundant in, moist woodland ravines; rare elsewhere in wooded situations. April, May. B.L.H., C.L.

142. *Ormosia frisoni* Alex.

Abundant in moist, wooded ravines and about rotting logs in floodplain woods. Late April, May. B.L.H., C.L. Mating swarms over logs, stumps and in ravines.

143. *Ormosia holotrichia* (O.S.)

3 ♂♂ from moist, shaded ravines. October 19, 1951. C.L.

4. 14*Ormosia ingloria* Alex.

Fairly common in moist, shaded ravines and on wet faces of shale banks. September, October. B.L.H., C.L.

145. *Ormosia meigenii* (O.S.)

3 ♂♂ from seepage area at foot of wooded slope. May 6, 1951. B.L.H.

146. *Ormosia nubila* (O.S.)

Abundant in moist, shaded ravines; common around decaying logs in floodplain woods; less numerous in beech-maple forests. Late April, May, September. B.L.H., C.L.

147. *Ormosia pygmaea* (Alex.)

Fairly common in moist, wooded ravines. May, September, October. B.L.H., C.L.

148. *Ormosia rubella* (O.S.)

Abundant in moist, shaded ravines; common in floodplain woods, less frequent in beech-maple forests. September, October. B.L.H., C.L., K.S.

149. *Molophilus cramptoni* Alex.

1 ♂ from moist, wooded ravines. June 15, 1952. B.L.H.

150. *Molophilus forcipulus* (O.S.)

1 ♂, 1 ♀ from wooded swamp. June 15, 1951. K.S.

151. *Molophilus hirtipennis* (O.S.)

Females fairly common in floodplain woods and in shaded ravines; less numerous in beech-maple forests. Late May, June. B.L.H., C.L. Males not collected.

152. *Molophilus pubipennis* (O.S.)

Several ♀♀ from floodplain woods and upland swamps. Late May, early June. B.L.H., C.L., K.S.

153. *Molophilus quadrispinosus* Alex.

1 ♂ from vegetation bordering woodland stream. May 12, 1952. C.L.

ACKNOWLEDGMENTS

I wish to acknowledge indebtedness to the late Dr. J. Speed Rogers previously of the Museum of Zoology, University of Michigan, who verified my determinations and identified puzzling specimens. He was a constant source of information and encouragement throughout the study. Dr. C. O. Berg formerly of Ohio Wesleyan University and now at Cornell was the initial force behind the study and has made many useful and valuable suggestions.

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A CHANGE IN EDITOR OF THE JOURNAL

Dr. Richard H. Böhning has recently resigned as editor of The Ohio Journal of Science.

The new Editor-in-Chief is Dr. Henry L. Plaine of the Department of Zoology and Entomology of The Ohio State University.

The editorial policy of the Journal will continue in the pattern established by previous editors. The Journal will welcome and publish papers in all fields of science. The papers may be either technical reports of new research, or expository and descriptive papers on aspects of science of general interest.

AN UNUSUAL CASE OF CONGENITAL HEART ANOMALY IN A WOMAN AGED TWENTY-FIVE YEARS

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Department of Anatomy, The Ohio State University, College of Medicine, Columbus 10

During the routine dissection in the Human Anatomy Laboratory, Ohio State University, College of Medicine, our attention was called by the students at one of the tables to the presence of an abnormal heart and arrangement of the great vessels in the cadaver they were dissecting. At our request the heart and remnants of the great vessels were preserved for future detailed study. Unfortunately during the removal of the specimen many of the vessels were not as well preserved as they should have been. It is on this material that we present the following description.

A unique feature of the findings is the age of the individual. According to the death certificate this person was a female born June 6, 1926 and died October 17, 1951, at the age of twenty-five. According to the clinical report obtained from the Orient State Institute, where she had been a patient since July 3, 1941, "her death was sudden. She was found to have a congenital heart anomaly, with clubbing of the fingers and toes, dyspnea and cyanosis. She had a mental age of two years with an I.Q. of 14. She was about 5'4" in height and weighed 120 pounds."

ANATOMICAL DESCRIPTION OF HEART

The external appearance of the heart can be seen in figure A, and it is to be noted that it is conical in shape without a well-marked apex. Its weight and measurements are normal.

The typical four chambers are present, although greatly modified. Thus, for example the auricle of the right atrium is enlarged and is more quadrilateral-shaped than the typical ear-shape. The openings of the venae cavae are normal. The (Eustachian) valve of the inferior vena cava (fig. C) is also normal in size and appearance, whereas, the Thebesian valve is quite pronounced in conformity with the markedly enlarged opening of the coronary sinus. A fossa ovalis is barely visible and there is no sign of a foramen ovale.

The cavity of the right ventricle (figs. C and D) is quite noticeably smaller than normal and its walls are greatly hypertrophied. The tricuspid valve is

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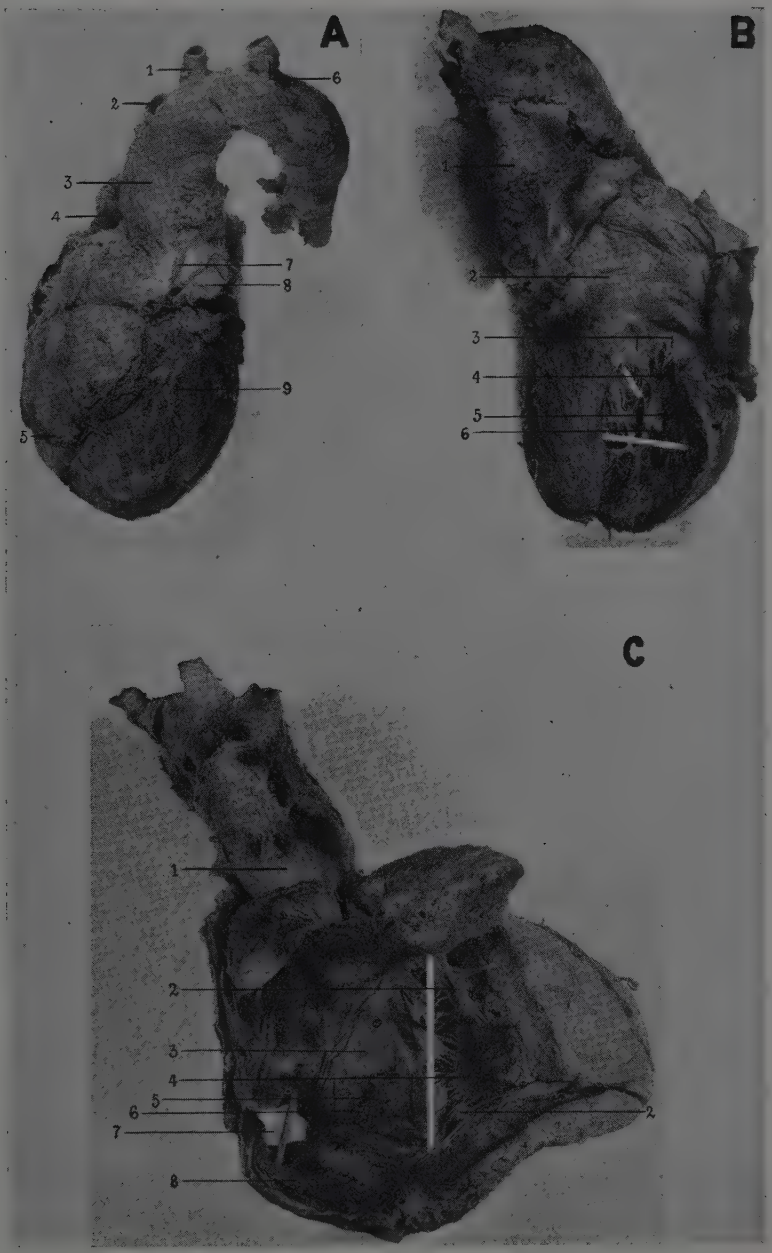
EXPLANATION OF FIGURES IN PLATE I

FIGURE A. In this figure the heart is shown more or less in the normal position, for ease of orientation and, therefore, shows the aortic arch to the left. Whereas, in the cadaver, the ventricles pointed to the left, the atria to the right and the aortic arch was also directed to the right (See Figs. C and E). 1—Right com. carotid art.; 2—Innominate art.; 3—Truncus arteriosus; 4—Right auricle; 5—Right ventricle; 6—Right subclavian art.; 7—Ligamentous structure; 8—Left auricle; 9—Left ventricle.

FIGURE B. In this figure the heart is also shown in a vertical position but is rotated to the right in order to expose the left chambers. 1—Truncus arteriosus; 2—Cavity of the left atrium; 3—Bicuspid valve; 4—Chordae tendineae; 5—Cavity of the left ventricle; 6—Papillary muscle.

FIGURE C. The heart in this figure is oriented according to the position it assumed in the cadaver, i.e. with the ventricles pointing toward the left, the atria toward the right and the aortic arch directed toward the right. 1—Truncus arteriosus; 2—Tricuspid valve cusps; 3—Cavity of the right atrium; 4—Cavity of the right ventricle; 5—Atrial opening of the coronary sinus; 6—Thebesian valve of coronary sinus; 7—Opening of the sup. vena cava; 8—Eustachian valve of inf. vena cava.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normal. It is to be noted (fig. A) that a conus arteriosus and pulmonary trunk are absent.

The auricle of the left atrium is of typical form (fig. A), although it is somewhat more triangular in shape than normal. The left atrium is abnormally large and extends to the right, posterior to the right atrium (fig. B), its right margin being located at the level of the atrial orifice of the superior vena cava. A single right pulmonary vein and two left pulmonary veins empty into the left atrium.

The left ventricle (figs. A and B) is normal but is much larger than the right. Its volume in comparison with that of the right ventricle is more than doubled. The mitral valve is normal.

The interventricular septum is deficient at its cranial end, due to the failure of its membranous portion to develop, as a result of which a communication exists between the two ventricles (fig. D). Correlated with this deficiency and with the absence of a pulmonary trunk, is the presence of a persistent single arterial trunk, the truncus arteriosus (figs. A-D). Obviously this single trunk serves to conduct the venous blood from the right side of the heart and the arterial blood from the left side.

TRUNCUS ARTERIOSUS

The orifice of the truncus arteriosus (fig. D) over-rides the septal defect and is situated slightly in front and to the left of the septal cusp of the tricuspid valve and directly to the right of the anterior cusp of the mitral valve. Thus, as regards its relation to the latter cusp its situation is similar to that of the aortic vestibule of the normal heart. The opening is provided with three well-developed semilunar cusps, each having a pronounced nodule (corpus Arantii). The cusps are located one on the right, one on the left and one posteriorly, the margin of the latter being roughened. The sinuses (of Valsalva) are large. In the right sinus is the opening of the right coronary artery, which seems to be unusually wide, and cranial to the left sinus is the opening of the left coronary artery. The latter opening is directed obliquely and is provided with a slight valve-like fold. Dissection of the coronary arteries proves them to take a normal course and to have typical branches of distribution.

Unfortunately no radiographs of this patient's chest were available and it is, therefore, difficult to determine the exact position which the heart and truncus arteriosus assumed in the living state. However, figure E, which was furnished to the authors by the students who dissected the body, shows that the arch of the truncus curved to the right rather than to the left and that the descending portion was situated on the right side of the thoracic cavity. It can also be seen in figure E that the branches of the arch are the reverse of the normal. Figures A, B, D fail to show these features because the heart and truncus arteriosus were photographed in a vertical position for ease of orientation.

EXPLANATION OF FIGURES IN PLATE II

FIGURE D. In this figure the heart and aortic arch are oriented in the normal position. However, in the cadaver it assumed the position as that shown in figures C and E. 1—Right subclavian art.; 2—Right com. carotid art.; 3—Innominate art.; 4—Truncus arteriosus (laid open); 5—Probe in right coronary art.; 6—Probe in left coronary art.; 7—Semilunar cusps; 8—Communication between the right and left ventricle; 9—Tricuspid valve; 10—Cavity of right ventricle; 11—Bronchial arteries; 12—Ligamentous structure; 13—Left auricle; 14—Interventricular septum.

FIGURE E. Schematic representation of the heart and vessels as actually found in the cadaver. 1—Truncus arteriosus; 2—Innominate art.; 3—Left subclavian art.; 4—Left common carotid art.; 5—Right common carotid art.; 6—Right subclavian art.; 7—Aortic arch; 8—Left bronchial arteries; 9—Right bronchial artery; 10—Left pulmonary veins; 11—Right pulmonary vein; 12—Right lung; 13—Left lung.

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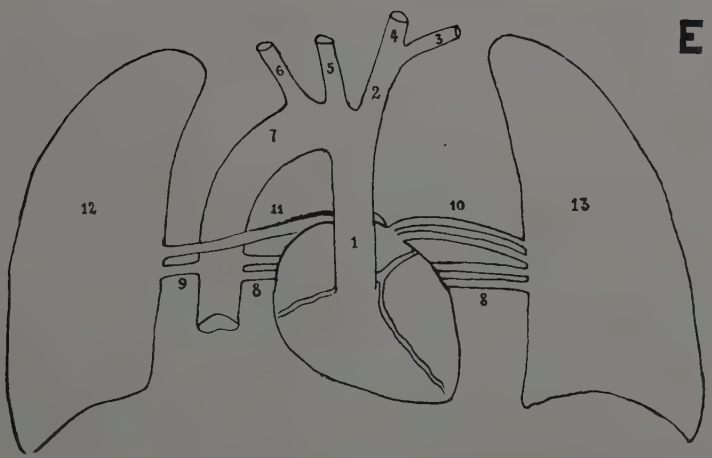
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Situated on the ventral aspect of the proximal end of the truncus arteriosus (figs. A and D) is a structure that is ligamentous proximally and bifurcates distally into two branches, each of which has a lumen. Unfortunately this structure is not illustrated in figure E and it is, therefore, impossible to determine what the original distribution of the two branches was before they were severed at the time the heart was removed from the body. The proximal end fuses with the wall of the truncus arteriosus inferior to the left semilunar cusp and the question arises as to whether this ligamentous structure should be considered an atretic pulmonary trunk.

Compensating for the absence of pulmonary arteries are three greatly dilated bronchial arteries, which branch from the descending portion of the truncus arteriosus, one to the right lung and two to the left lung (figs. D and E). They correspond in number with the pulmonary veins.

There is no evidence of a ligamentous ductus arteriosus. However, a well-defined vestigial fold of Marshall is present. In the absence of a left pulmonary artery it extends from the region of the left bronchial arteries to the left pulmonary veins, where the latter empty into the left atrium. Cardiac veins present a normal pattern and drain into the coronary sinus which is markedly enlarged (fig. C).

DISCUSSION

The question arises as to the classification of the present cardiac anomaly. Obviously it cannot be diagnosed as Tetralogy of Fallot, inasmuch as the latter is characterized, among other cardiac defects, by pulmonary stenosis. Pulmonary arteries are absent in the present case. According to some authorities, notably Abbott (1936), Humphrey (1932) and Kugel (1931), the condition known as Truncus Arteriosus Communis Persistens is characterized by the presence of a single large arterial trunk leading from the heart and giving rise to coronary, pulmonary and systemic vessels, by a high interventricular defect, by a patent foramen ovale and by a tremendously enlarged heart, especially the right ventricle. Moreover, as Taussig (1947) points out, in cases of a persistent pulmonary artery arising from a common truncus arteriosus there is adequate circulation to the lungs, a large volume of oxygenated blood is mixed with venous blood and, therefore, cyanosis is minimal or absent.

Opposed to the "true" form of truncus arteriosus is the so-called "pseudo" form, or as it is sometimes called, Truncus Solitarius Aorticus. The latter condition is characterized by atresia of the pulmonary artery, due to the failure of the sixth aortic arches to develop, only a vestige of which persists as a ligamentous structure ending blindly at the heart. In this condition circulation to the lungs can only be by way of bronchial arteries, which become greatly enlarged, in order to accommodate the large volume of blood. According to Taussig (1947) the bronchial arteries are never sufficiently great to permit adequate circulation to the lungs; a small volume of oxygenated blood is mixed with a large volume of venous blood and consequently cyanosis is intense.

Clubbing of the distal phalanges of the fingers and toes in congenital heart disease is claimed to be proportional to the degree of cyanosis present and is related to a state of chronic passive congestion of the capillaries of the nail bed. Cyanosis is always manifested before clubbing, the earliest sign of the latter being a thickening of the nail beds of the index fingers and thumbs. The skin covering the distal phalanges of the digits becomes smooth and shiny and of a lilac hue, while at the same time the base of the nail gradually becomes raised, the basal angle of the nail and digit is obliterated, increased curvature of the nail in both directions gradually develops and finally the tips of the digits become broadened resembling a drumstick in appearance. This condition is attributed indirectly to the low degree of oxygenation of the blood which is due in part to the admixture

of arterial and venous blood from both ventricles prior to its passage into the single arterial trunk and in part to the amount of blood delivered to the lungs for aeration. When circulation to the lungs is by way of bronchial arteries, even though they are enlarged, as in the present described case, the pulmonary blood flow is inadequate, and, therefore, there is intense cyanosis, with peripheral stasis in the capillaries which become dilated. Clubbing of the fingers and toes is attributed directly to passive congestion of the capillaries of the nail-bed, to edema of the connective tissue between the nail-bed and the bone and to the resultant anoxemia, sluggish circulation, increased local deoxygenation and accumulation of metabolites (Brown, 1950).

In view of the anatomical findings and case history of the patient it would seem, therefore, that the present cardiac anomaly may be diagnosed as Truncus Solitarius Aorticus. This type of cardiac defect is not uncommon. However, the present case is unique because of the survival of the patient to the age of twenty-five. Taussig (1947) claims that cardiac anomalies of this sort are incompatible with life, usually the prognosis is extremely poor and "the vast majority of infants die within the first few weeks of life." Schnitker (1952) likewise points out that the prognosis is generally grave but is somewhat better in those cases in which pulmonary arteries arise directly from the common arterial trunk—"In such cases individuals have survived to the age of 18, 22, 25 and 33 years." One of Abbott's cases (1927) in the latter category lived to be 25 and Carr, Goodale and Rockwell (1935) described a patient who survived to the age of 36 years and two months.

A thorough review of the literature revealed but one case closely similar to the present one that survived for as long as 25 years. That case was reported by Zimmermann (1927), who incidentally classified it as truncus arteriosus communis, notwithstanding his claim that pulmonary arteries were absent. His case differed from the present one in the following particulars: there was no clubbing of the terminal phalanges, the common arterial trunk arose from the left side of the base of the heart, the cavity of the right atrium was approximately three times the size of the left, the three branches of the aortic arch arose in the normal manner, the descending aorta was on the left side, there were two pulmonary veins which united to form a common trunk from each lung and there were three right and two left bronchial arteries arising from the descending aorta.

SUMMARY AND CONCLUSIONS

1. An unusual anomalous heart found in a twenty-five year old female cadaver in the Human Anatomy Laboratory, Ohio State University, is described.

2. The most outstanding morphological features of this heart are (a) the absence of a conus arteriosus and pulmonary trunk; (b) the presence of a single large arterial trunk which combines the functions of a systemic and pulmonary circulation; (c) greatly dilated bronchial arteries arising from the descending aorta is the only means whereby blood reaches the lungs; (d) there is a high interventricular septal defect, at which point the orifice of the single arterial trunk, guarded by three semilunar valves, is located; (e) there is no evidence of a ligamentum ductus arteriosus or fossa ovalis; (f) a ligament situated on the ventral aspect and parallel with the single arterial trunk suggests an atretic pulmonary artery; (g) the aortic arch and descending aorta are on the right rather than on the left side, the three branches of the arch being the reverse of normal; (h) the right auricle and the opening of the coronary sinus in the right atrium are enlarged, the latter space being normal in size; (i) the right ventricle has less than half the capacity of the left ventricle, its walls being greatly hypertrophied; (j)the cavity of the left atrium is more spacious than that of the right atrium, and (k) its weight and measurements are normal.

3. In view of the clinical history of the patient and of the anatomical findings in the present described case of cardiac anomaly it is concluded that the anomaly

should be classified as Truncus Solitarius Aorticus. Although this condition is not uncommon it is incompatible with life and usually terminates fatally within a few weeks following birth. The rarity of the described case is confirmed by a review of the literature which reveals only one other reported case of the same survival period, the anatomical findings, however, were not comparable in all details.

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A PROPORTION METHOD FOR SAMPLING SPITTLEBUG POPULATIONS

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THE PROBLEM

Insect control is usually evaluated by comparisons of "treated" and "check" counts of (1) number of insects per unit or (2) proportion of infested units. Insects per unit is an actual measure of insect population while proportion of infested units may be more a measure of crop loss than it is of insect population. (*e.g.*, the presence of a single worm in a fruit renders the fruit as valueless as several worms in a fruit. In this example a measure of crop loss, proportion of infested, is more important than a measure of insect population.) There are many examples, however, where proportions of infested units are used as estimates of insect population. Both methods have been employed by research workers to estimate infestations of the meadow spittlebug, *Philaenus leucophthalmus* (L.). In one method a set number of stems are randomly selected and the number of nymphs on each stem is counted and recorded. The counts are then expressed as nymphs per stem. In the other method a set number of stems are randomly selected and the number having one or more spittlebugs present is recorded. The counts are expressed as a proportion or percentage of stems infested.

The nymphs per stem method, which is an actual population measure, has the disadvantage of being laborious since every stem must be examined carefully and each nymph discovered and counted. The proportion infested stems method is more rapid since as soon as one nymph is found the stem is recorded as infested. The disadvantage lies in the fact that the stem with many nymphs has no more weight in the final proportion value than does a stem with only one nymph. The method is therefore less precise in estimating actual insect population.

In spittlebug control the aim is to compare insect populations since the presence of a single nymph on a stem does not constitute complete loss of the crop. The question at hand is therefore, "How good an estimator of insect populations is the proportion of infested stems?" There should be some relationship between the two methods. If this relationship could be expressed mathematically, the counts obtained by one method could be converted into the values obtained by the other. It is this mathematical relationship that will be described in the present work.

METHODS

During the 1952–53 seasons sufficient data were collected to provide an empirical test of the relationship of the nymphs per stem (N/S) counts of proportion infested (PI). Records of nymphs on individual stems were kept so that the N/S counts also provided a PI count. In the various experimental trials that were conducted the treatments were usually replicated four times. The practice was to count nymphs on each of 25 stems in each plot of the experiment. Therefore the data used were in sets of 25 from which both a N/S and a PI count could be obtained. During the two seasons, 457 sets of 25 stems each of alfalfa and 247 of red clover were obtained. The counts from red clover were treated separately from those of alfalfa since it is conceivable that the characteristic counts might be different.

Among the sets obtained, there were PI counts that fell in every category from 1 infested in 25 counted to 25 infested in 25 counted. The PI value for each of these categories was therefore .04, .08, .12, . . . , 1.00. All of the N/S

counts that corresponded to a particular PI category were combined and a mean N S count determined. The first three columns of Tables 1 and 1A show the PI determination, the number of observed sets, and the corresponding mean N S.

The corresponding N/S and PI counts can be plotted using PI values as the abscissas and the N/S values as the ordinates. A line fitted through these points should represent the relationship between the two variables. Since the proportions were evenly spaced the method of Orthogonal Polynomials, Anderson and Houseman (1942), could be used to fit the regression line. This method was utilized and the formula obtained for the predicted value of the mean N/S was

$m = 0.40p + 12.53p^2 - 32.63p^3 + 29.38p^4$ for red clover

$m = 1.09p + 3.95p^2 - 8.00p^3 + 10.39p^4$ for alfalfa

where p equals the proportion of stems infested.

The formula computed from the empirical data enables us to predict the N S count from the PI count. Column 4 of Tables 1 and 1A shows the mean N/S predicted by the regression formula.

Bowen (1945) and Wadley (1954) discuss the limitations of using counts of the proportion of noninfested (or infested) plants to estimate insect populations. Bowen was able to use proportion noninfested to estimate mean leafhopper counts from mathematical theory because the counts conformed to the Poisson distribution. As both Bowen and Wadley point out the most severe limitation of

TABLE 1

Red Clover

IS/25	No. Sets	Obs. m	m	Obs. s	s
1	37	.04	.03	.23	.22
2	31	.09	.10	.34	.41
3	13	.16	.18	.49	.58
4	15	.23	.27	.61	.73
5	12	.40	.37	1.18	.86
6	7	.43	.46	.92	.98
7	7	.43	.56	.94	1.09
8	4	.75	.65	1.96	1.21
9	4	.80	.74	1.62	1.32
10	7	.85	.83	1.70	1.45
11	4	.99	.92	1.60	1.59
12	3	.91	1.08	1.21	1.74
13	9	1.33	1.15	2.11	1.92
14	6	1.16	1.31	0 59	2.14
15	5	1.38	1.51	1.89	2.38
16	7	1.86	1.76	2.30	2.65
17	6	2.30	2.09	3.15	3.00
18	4	2.26	2.50	2.54	3.33
19	10	3.34	3.02	3.59	3.74
20	11	3.71	3.66	4.64	4.24
21	11	4.43	4.46	4.02	4.73
22	8	5.17	5.43	5.19	5.43
23	12	6.58	6.60	5.58	6.02
24	11	7.27	8.01	6.14	6.83
25	3	10.41	9.67	7.30	7.64

IS/25 = Infested stems in 25 total
No. Sets = Number of observed sets
Obs. m = Observed mean number of nymphs per stem
m = Means number of nymphs per stem predicted by regression
Obs. s = Observed standard deviation of individual counts
s = Standard deviation of individual counts predicted by regression

the method comes about under high infestations where the variability becomes so large that the noninfested counts are poor estimators of the mean. In the present study the distribution of the counts needed to be determined and the variances over the entire range of proportions estimated.

The distributions of the N/S counts under any given proportion infested were fitted to the Poisson and the negative binomial. In general, the Poisson did not provide a good fit, while at most levels the negative binomial seemed satisfactory. Because of its complexity, estimation of the variance from theory using the negative binomial did not seem as feasible as the following empirical procedure which was used.

Column 3 of tables 1 and 1A contains the observed mean N/S for all of the counts under a particular PI. Using these same data, an estimate of variance was obtained from the counts under each PI. The observed standard deviation (square root of variance) is tabulated in column 5 of tables 1 and 1A. A regression line was fitted to these points using the method of Orthogonal Polynomials with the resulting formulas.

$s = 5.95p - 10.81p^2 + 12.50p^3$ for red clover

$s = 7.422p - 14.40p^2 + 14.75p^3$ for alfalfa

where p equals the proportion of stems infested.

TABLE 1A

Alfalfa

IS/25	No. Sets	Obs. m	m	Obs. s	s
1	44	.05	.05	.25	.26
2	26	.12	.11	.60	.51
3	26	.19	.18	.68	.61
4	18	.25	.25	.70	.88
5	24	.33	.33	.84	1.03
6	19	.37	.42	.80	1.16
7	18	.52	.50	1.14	1.27
8	12	.52	.60	.99	1.38
9	13	.66	.71	1.12	1.49
10	13	.92	.82	1.77	1.61
11	21	1.01	.95	1.75	1.73
12	17	1.02	1.10	1.58	1.87
13	13	1.25	1.27	1.73	2.03
14	19	1.62	1.47	2.28	2.23
15	17	1.50	1.70	1.91	2.46
16	9	2.16	1.96	3.06	2.71
17	25	2.50	2.28	3.22	3.06
18	21	2.66	2.64	2.74	3.36
19	16	3.17	3.07	3.66	3.76
20	22	3.49	3.56	4.00	4.27
21	18	3.66	4.13	3.59	4.75
22	17	4.50	4.80	4.89	5.50
23	12	5.99	5.56	6.67	6.07
24	9	6.09	6.43	5.59	6.93
25	8	7.76	7.42	7.50	7.77

IS/25 = Infested stems in 25 total
No. Sets = Number of observed sets
Obs. m = Observed mean number of nymphs per stem
m = Mean number of nymphs per stem predicted by regression
Obs. s = Observed standard deviation of individual counts
s = Standard deviation of individual counts predicted by regression

In addition to the predicted mean N/S there is now available a corresponding predicted standard deviation of the N/S. The values for this predicted standard deviation are tabulated in column 6 of tables 1 and 1A.

After the estimation of a mean N/S and the standard deviation, the next step is to compute the confidence limits of a mean determined from counts of twenty-five or some other logical number of stems. Since 25 and 100 stems have been used as units in the experimental work at the Ohio Agricultural Experiment Station the standard deviation of sample means of 25 and 100 was computed for each proportion of infested stems. The standard deviation of sample means (standard error) was computed by dividing standard deviation, predicted by the regression line, by the square root of the number of observations constituting the sample mean. These values are tabulated in columns 3 and 6 of tables 2 and 2A.

The standard error term was multiplied by 1.96 and the result subtracted from and added to the predicted mean. The lower value was taken as the lower limit of the mean and the upper value the upper limit of the mean at the 95 percent confidence level. The determination of the 95 percent confidence limits by this method depends upon the counts being normally distributed. The counts are not so distributed as has been shown. From the standpoint of practical procedure,

TABLE 2

Red Clover

			95% limits–25			95% limits–100	
p	m	$S\bar{x}_{25}$	lower	upper	$S\bar{x}_{100}$	lower	upper
.04	.03	.04	0	.11	.02	0	.07
08	.10	.08	0	.26	.04	0	.18
.12	.18	.12	0	.42	.06	.06	.30
.16	.27	.14	0	.54	.07	.13	.41
20	.37	.17	.04	.70	.09	.19	.55
24	.46	.20	.07	.85	.10	.26	.66
28	.56	.22	.13	.99	.11	.34	.78
32	.65	.24	.18	1.12	.12	.41	.89
36	.74	.26	.23	1.25	.13	.49	.99
40	.83	.29	.26	1.40	.15	.54	1.12
44	.92	.32	.29	1.55	.16	.61	1.23
48	1.08	.35	.39	1.77	.17	.75	1.41
52	1.15	.38	.44	1.89	.19	.76	1.52
.56	1.31	.43	.47	2.15	.21	.90	1.72
.60	1.51	.48	.57	2.45	.24	1.04	1.98
.64	1.76	.53	.72	2.80	.27	1.23	2.29
.68	2.09	.60	.91	3.27	.30	1.50	2.68
72	2.50	.66	1.21	3.79	.33	1.85	3.15
76	3.02	.75	1.55	4.49	.37	2.29	3.75
80	3.66	.85	1.99	5.33	.42	2.93	4.39
84	4.46	.91	2.68	6.24	.46	3.56	5.36
88	5.43	1.09	3.29	7.57	.54	4.37	6.49
92	6.60	1.20	4.25	8.95	.60	5.42	7.78
96	8.01	1.37	5.66	10.36	.68	6.68	9.34
1.00	9.67	1.53	6.67	12.67	.76	8.18	11.16

p = Proportion infested stems
m = Predicted mean nymphs per stem
$S\bar{x}_{25}$ = Standard deviation of mean of 25 stems
95% limits–25 = 95% confidence limits of prediction of nymphs per stem by counts of 25 stems
$S\bar{x}_{100}$ = =Standard deviation of mean of 100 stems
95% limits–100 = 95% confidence limits of prediction of nymphs per stem by counts of 100 stems

however, it did not seem worthwhile to try to estimate a negative binomial distribution for each proportion of infested stems and determine the 95 percent point of each individual distribution. In the absence of this latter group of determinations the $\pm 1.96 \cdot s_{\bar{x}}$ value was used. Columns 4, 5, 7, and 8 of tables 2 and 2A contain these limits. The following discussion will show that this approximation was apparently close enough for acceptable results.

TEST OF ACCURACY

The basic equations for the mean and the standard deviation were computed from data obtained in Ohio during the 1952–53 seasons. If the formulas were to be useful, they should apply universally. Data obtained during other seasons and in other locations were tested. In Ohio in 1954–55, 283 sets of 25 stems each of red clover and 166 sets of 25 alfalfa stems were evaluated for nymphs per stem and proportion of infested stems. The actual number of nymphs per stem was compared with the number predicted by the regression formula. Two hundred and sixty-five of the nymphs per stem values for red clover and 165 of the values for alfalfa fell between the limits of the predicted mean plus or minus 1.96 standard

TABLE 2A

Alfalfa

			95% limits–25			95% limits–100	
p	m	$S\bar{x}_{25}$	lower	upper	$S\bar{x}_{100}$	lower	upper
.04	.05	.05	0	.15	.03	0	.11
.08	.11	.10	0	.31	.05	.01	.21
.12	.18	.12	0	.42	.06	.06	.30
.16	.25	.18	0	.60	.09	.07	.43
.20	.33	.21	0	.74	.10	.13	.53
.24	.42	.23	0	.87	.12	.18	.66
.28	.50	.25	.01	.99	.13	.25	.75
.32	.60	.28	.05	1.15	.14	.33	.87
.36	.71	.30	.12	1.30	.15	.42	1.00
.40	.82	.32	.19	1.45	.16	.51	1.13
.44	.95	.35	.26	1.64	.17	.62	1.28
48	1.10	.37	.37	1.83	.19	.73	1.47
52	1.27	.41	.47	2.07	.20	.88	1.66
56	1.47	.45	.59	2.35	.22	1.04	1.90
60	1.70	.49	.74	2.66	.25	1.21	2.19
64	1.96	.54	.90	3.02	.27	1.43	2.49
68	2.28	.61	1.08	3.48	.31	1.67	2.89
.72	2.64	.67	1.33	3.95	.34	1.97	3.31
.76	3.07	.75	1.60	4.54	.38	2.33	3.81
.80	3.56	.85	1.89	5.23	.43	2.72	4.40
.84	4.13	.95	2.27	5.99	.48	3.19	5.07
.88	4.80	1.10	2.64	6.96	.55	3.72	5.88
.92	5.56	1.21	3.19	7.93	.61	4.36	6.76
.96	6.43	1.39	3.71	9.15	.69	5.08	7.78
1.00	7.42	1.55	4.38	10.46	.78	5.89	8.95

p = Proportion infested stems
m = Predicted mean nymphs per stem
$S\bar{x}_{25}$ = Standard deviation of mean of 25 stems
95% limits–25 = 95% confidence limits of prediction of nymphs per stem by counts of 25 stems
$S\bar{x}_{100}$ = Standard deviation of mean of 100 stems
95% limits–100 = 95% confidence limits of prediction of nymphs per stem by counts of 100 stems

errors. Therefore, 95.32 percent of the 449 samples fell within the computed 95 percent confidence limits.

Mr. Clarence White of the Illinois Natural History Survey provided the authors with data from 43 sets of 100 alfalfa and red clover stems taken in Illinois in 1952–53. Thirty-nine (90.7%) of the nymphs per stem values fell within the limits of the predicted mean plus or minus 1.96 standard errors.

Apparently data gathered at different locations and in different seasons fit the predicted means and standard deviations computed by the described method.

USE

The immediate practical use of this study to anyone interested in evaluating spittlebug populations is obviously that of estimating nymphs per stem from a proportion of infested stems count. After the proportion of infested stems is determined, the regression formula may be solved for an estimate of the mean nymphs per stem. This has been done and tabulated for proportions which are divisible by .04. Tables 2 and 2A may be entered under column 1 (proportion of infested stems) and the predicted number of nymphs per stem found from column 2. If the proportion infested in a total of 25 or 100 is obtained, the upper and lower limits of the mean may be obtained from columns 4 and 5 or 7 and 8.

Tables 3 and 3A tabulate the differences that can be discovered using 25 and 100 stem samples. These differences are computed on the basis of the estimated

TABLE 3

Red Clover

	At 95% confidence level a 25 stem sample is		At 95% confidence level a 100 stem sample is	
p	greater than	less than	greater than	less than
.04	——	.28	——	.16
.08	——	⩽ .40	——	.20
12	——	.52	——	.28
16	——	.60	.04	⩽ .32
20	——	.64	.08	.44
24	——	.68	.08	.48
.28	.04	.72	.12	.56
32	.04	.72	⩾ .16	.56
.36	.04	.76	.16	.60
.40	⩾ .08	.76	.16	.64
44	.08	⩽ .76	.20	⩽ .64
.48	.08	.80	.24	.64
52	.12	.80	.24	.72
56	.12	.84	.32	.72
60	.16	.84	.36	.76
64	.20	.88	⩾ .44	⩽ .76
68	.24	.88	.48	.80
72	.32	.92	.56	.84
76	⩾ .44	.96	⩾ .64	.88
80	.52	.96	.68	.92
84	.60	1.00	.72	.92
88	.68	——	.76	.96
.92	.72	——	.84	1.00
.96	.80	——	.88	——
1.00	.84	——	.92	——

p = Proportion infested stems

nymphs per stem rather than on the variance of the proportion of infested stems. An example of the use of the tables follows.

Suppose that 100 red clover stems are examined and 56 are found to be infested with one or more nymphs. The proportion of infested stems is then 0.56. Enter table 2 in column 1 at 0.56. Read the predicted nymphs per stem in column 2, 1.31. One point three one nymphs is therefore the best prediction of the nymphs per stem in the plot from which the stems were taken. From Table 2, column 6, find the standard error, 0.21. The 95 percent confidence limits may be found in columns 7 and 8, 0.90 to 1.72. From this 100 stem sample we may conclude that the true mean lies somewhere between 0.90 and 1.72. Looking at table 3, column 1, opposite 0.56 we find in columns 4 and 5 the values 0.32 and 0.72. These figures represent the proportions of infested stems which are different from our sample of 0.56. Therefore, if another field or another treatment has a true proportion of infested stems of less than 0.32 or more than 0.72, we could conclude that the population in the sample field was different.

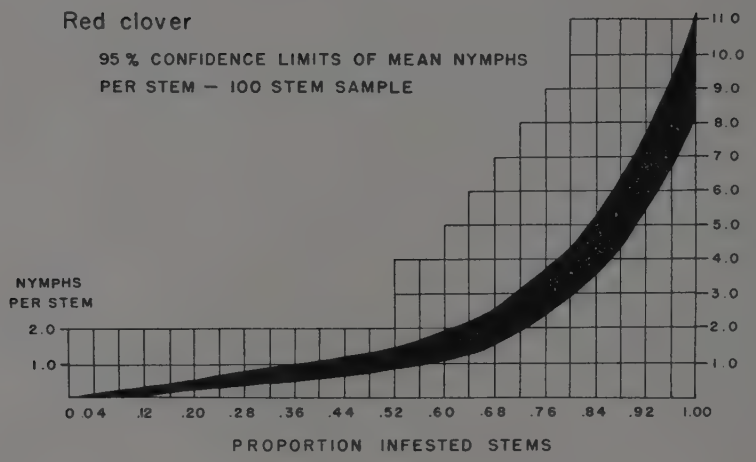
For graphic estimates of the nymphs per stem from counts of the proportion infested, figures 1 and 1A have been prepared. Enter the graph along the bottom at the appropriate proportion. Follow upward to the point of interception of the black area. Follow across to the scale at the side to find the lower limit of the mean nymphs per stem of a 100 stem sample. The point of interception of the top of the black area indicates the upper limit of the mean of a 100 stem sample.

TABLE 3A

Alfalfa

	At 95% confidence level a 25 stem sample is		At 95% confidence level a 100 stem sample is	
p	greater than	less than	greater than	less than
.04	——	.40	——	.20
.08	——	.48	——	.28
.12	——	.52	——	.32
.16	——	⩽ .60	——	.40
.20	——	.60	.04	.44
.24	——	.64	.04	.48
.28	——	.68	.08	.52
.32	——	.72	.12	.52
.36	——	.72	.12	.56
.40	.04	.76	.16	.60
.44	.04	.80	.20	.64
.48	.08	.80	.24	.68
.52	.12	.84	.32	.68
.56	.12	.88	.36	.72
.60	⩾ .20	.92	.40	.76
.64	.24	.92	.44	.80
.68	.28	.96	.52	.84
.72	.36	1.00	.56	.88
.76	.40	——	.60	.92
.80	.48	——	.64	.96
.84	.52	——	.68	.96
.88	.56	——	.72	1.00
.92	.64	——	.76	——
.96	.68	——	.84	——
1.00	.72	——	.88	——

p = Proportion infested stems



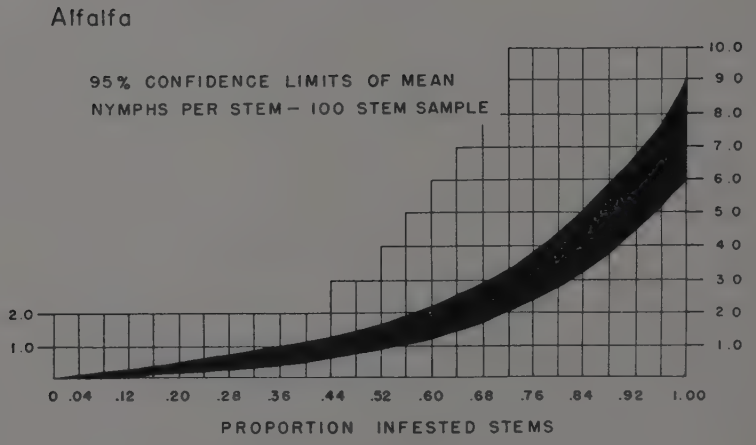


FIGURE 1 (above) and FIGURE 1A (below)

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ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE
1956

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REPORT OF THE SIXTY-FIFTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

The 65th annual meeting was held on the campus of Wittenberg College at Springfield on April 19, 20, and 21, 1956. Dr. William C. Beaver, general chairman, and his local committee made the arrangements for the meetings. This was the second Wittenberg meeting, the first being held in 1929. The Executive Committee met at 3:00 p.m. and the council met at 8:00 p.m. on April 21 for the transaction of business.

On Friday, April 20, ten sections and one subsection held meetings in the following fields: Zoology, Plant Sciences, Subsection on Genetics, Geology, Medical Sciences, Physics and Astronomy, Geography, Chemistry, Science Education, Anthropology and Sociology, and Conservation. At the conclusion of the sectional meetings, Dr. John R. Mayor, director of the Science Teaching Improvement Program of the A.A.A.S., spoke on "Responsibility of Scientists and Science Departments for the Science Program of Secondary Schools." The Ohio Section of the American Physical Society met in joint session with the section of Physics and Astronomy on Saturday, April 21. The eighth annual State Science Day of the Junior Division was held on April 22 with the largest number of student projects in the history of the Junior Division. Commercial exhibits were presented by three companies. A tour for the ladies in attendance was taken to visit the Crabill Art Center and the new Weaver chapel and library. A tea was then served at the president's home. The wives of faculty members in the science departments of Wittenberg College served as hostesses. On Saturday, April 21, an all-day field trip was enjoyed by four bus loads of members from the sections of Plant Sciences, Geology, and Conservation which jointly sponsored the excursion. Inter-relationships of these fields were brought out in a study of the glacial geology, vegetation, and conservation activities in the Springfield area.

The annual banquet and business meeting was held in the dining room of the Woodlawn Hall at 6:00 p.m., April 20. Dr. W. C. Beaver acted as toastmaster. Greetings from Wittenberg College were given by President C. C. Stoughton, and a response for the Academy was given by Dr. K. G. A. Busch. Dr. Paul Rothemund, president of the Academy, delivered the presidential address, entitled, "Hemin and Chlorophyll—the Two Most Important Pigments for Life on Earth."

An election of officers was held for the following: president, secretary, treasurer, director of public relations, librarian, and a member of the trustees of research funds, necrology committee, and resolutions committee, the results of which appear at the beginning of this annual report. The secretary presented a summary of our present membership and announced the following as newly elected Fellows of the Academy with their respective section letter:

A—Acker, G. G.
C—Bates, R. L.
C—Brant, R. A.
G—Brown, G. H.
E—Cherrington, E. H.
H—Dudley, F. M.
C—Foreman, Fred
C—Foster, W. R.
H—Hornbrook, W. H.
H—Hoskins, A. A.
F—Hunker, H. L.
C—Levinson, A. A.
C—Lindberg, G. D.
C—Marshall, H. E.
B—Norstog, K. J.
C—Phelps, W. B.
J—Price, W. B.
H—Read, P. M.
J—Redett, R. B.
G—Reinheimer, J. D.
C—Rice, W. A.
I—Schaefer, J. E.
B—Shirling, E. B.
J—Slipher, J. A.
C—Smyth, Pauline
C—Sweet, W. C.
C—Weiss, M. P.
G—Yalman, R. G.

Mr. R. E. McKay, executive secretary of the Junior Division, announced the annual awards to outstanding high school teachers and the Kroger awards for outstanding work in science for each district.

Dr. W. H. Shideler presented resolutions prepared by the Resolutions Committee.

Respectfully submitted,

Ralph W. Dexter, *Secretary*

REPORT OF THE EXECUTIVE COMMITTEE AND THE COUNCIL

The Executive Committee met on December 2, 1955, and again on April 19, 1956; the Council met on December 3, 1955, and again on April 19, 1956. The fall meetings were held at Ohio State University while the spring meetings were held at Wittenberg College in Springfield. Following is a brief summary of the more important actions taken. After an extended discussion, it was decided not to affiliate the Junior Division with the National Science Fair. Two gifts of $50 each presented to the Academy by Dr. C. M. Goethe of California were assigned to the work of the Junior Division. It was decided to support the Academy Conference with a donation of $1 for each one hundred members in our Academy. Dr. J. R. Coash was selected to be recommended to the president of Bowling Green University for appointment as local chairman for the 1957 annual meeting. It was decided that in the future, the annual membership list would be prepared in the fall rather than in the spring in order to compile the membership at a time when it was at its most stable point. The Kettering Foundation presented the Academy with a gift of $750 to balance the books of the Ohio Journal of Science. The Trustees of the Research Funds announced the award of $150 for the support of two research projects. After a lengthy discussion on the present situation regarding the teaching of science and mathematics in high schools, President Rothemund was authorized to appoint a temporary committee to study matters pertaining to the training and certification of teachers of science and mathematics.

At the Wittenberg meetings, Dr. E. Lucy Braun reported on the historical development and accomplishment to the present time of the Ohio Flora Committee which has been a continuing temporary committee of the Academy. A request for financial aid submitted to the National Science Foundation in the name of the Academy was rejected because the project was considered too wide in scope for a single grant. Accordingly, it was recommended that a reduced request be made to finance the unit on the Woody Plants of Ohio supervised by Dr. Braun. The Executive Committee took action to revise the request as suggested under the auspicies of the Ohio Academy of Science. The Ohio Flora Committee was reappointed with commendation for its excellent work.

The secretary announced that beginning with January 1, 1957, funds allocated to state academies of science by the A.A.A.S. must be used for projects of high school students or, in special cases, for undergraduate students in small colleges. A.A.A.S. funds will no longer be available for research by faculty members and graduate students.

The Executive Committee accepted an invitation to meet for its annual meeting in 1961 at the University of Cincinnati. The committee formerly in charge of revising the constitution, consisting of Drs. Popham, Blaydes, and Tidd, was reconstituted to re-examine the constitution for possible changes and additions.

At the meeting of the Council, a motion was passed to make available for research purposes, a grant from our general fund equal to that given to the Academy for use by high school pupils since this money will no longer be available for research purposes. Such is to be done for one year until other provisions can be made to continue the research funds. Dr. Lovenstein was appointed to study the matter of forming a section in engineering, and Dr. Shaffer was appointed to study enlarging the present section of anthropology and sociology to a section on social sciences. The Academy membership as of April 4, 1956, was 1,196 and distributed among the sections as follows: A–278, B–198, C–181, D–111, E–64, F–39, G–111, H–94, I–27, J–93. The 1957 annual meeting was scheduled for Bowling Green State University at Bowling Green on April 18, 19, 20.

Respectfully submitted,

Ralph W. Dexter, *Secretary*

REPORT OF THE TREASURER
FISCAL YEAR 1955

ACADEMY BUSINESS	*1955*	*1954*
RECEIPTS:		
Bank Balance, January 1	$3,853.96	$3,380.04
Membership Dues	4,175.50	4,314.00
Sale of Publications	42.34	6.42
Interest U. S. Bonds	47.50	47.50
Exhibitor Fees (Commercial)	50.00	75.00
Gift, Charles F. Kettering Foundation	750.00	.....
Gift, C. M. Goethe	.....	25.00
Refund on cost of U. S. Bonds	.....	6.88
Miscellaneous	.....	75.10
Junior Academy	746.30	.....
	$9,665.60	$7,929.94
EXPENDITURES:		
Subscriptions and Engraving, Ohio Journal of Science	$3,047.06	$2,847.93
Printing Annual Report	118.18	82.04
Printing announcements and notices	326.30	212.50
Postage, office supplies, bank charges, auditing, and other administrative expenses	624.67	661.76
Junior Academy	734.11	266.75
Academy Conference	11.74	5.00
Bank Balance, December 31	4,803.54	3,853.96
	$9,665.60	$7,929.94
Excess income over expense	$ 917.08	$ 473.92

RESEARCH FUND		
RECEIPTS:		
Bank Balance, January 1	$ 233.85	$ 197.33
Interest on Savings Account	53.34	18.99
Interest on U. S. Bonds	7.50	7.50
Dividends, Banc Ohio Stock	41.25	32.50
Grant, A.A.A.S.	369.50	190.00
	$ 705.44	$ 446.32
EXPENDITURES:		
Grants		$ 190.00
Harold G. Multer	35.00	.....
Ohio Flora Committee	212.00	.....
John R. Coash	100.00	.....
Robert E. Woodruff	50.00	.....
Harold C. Fritts	100.00	.....
Robert W. Long	50.00	.....
Bank Charges	2.65	3.48
Interest still in Savings Account	34.35	18.99
Bank Balance, December 31	121.44	233.85
	$ 705.44	$ 446.32
Excess income over expense, 1954		$ 55.51
Excess expense over income, 1955	$ 97.05	.....

Respectfully submitted,

ELTON F. PADDOCK, *Treasurer*

REPORT OF THE TRUSTEES OF THE RESEARCH FUND
FISCAL YEAR 1955

In the fiscal year of 1955 the trustees awarded research grants to five Academy members and the Ohio Flora Committee, totaling $547.00. The financial records of the trustees is included in the treasurer's report above.

Respectfully submitted,

G. W. BLAYDES, *Chairman*
R. P. GOLDTHWAIT
H. V. KNORR

REPORT OF THE ACADEMY LIBRARIAN FOR 1955

The Librarian is pleased to inform the Academy that its official journal is used in four hundred and ninety-eight exchanges. Seventy-four percent of these exchanges are with institutions located abroad. Twenty-six percent of the exchanges are with domestic institutions. Since the last annual report seventeen additional exchanges have been concluded. As a result of bringing our mailing list up-to-date, we note that our total number of exchanges is the same as that of the report for 1954.

Sales of the Academy's publications for the period July, 1955 through April, 1956 amounted to seven dollars and fifteen cents ($7.15). This sum was turned over to the Treasurer of the Academy.

Respectfully submitted,

MORTON COBURN, *Librarian*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the joint administrative board of The Ohio Journal of Science was held at Columbus on April 14, 1956. The meeting was called to order by board chairman Spieker. Present were Mr. Spieker and Mr. Meyer representing the Ohio State University, Mr. Hoel representing the Ohio Academy of Science, and Mr. Bohning, Mr. Popham and Mr. Fisk of the Ohio Journal of Science staff. Mr. Lindsey was unable to attend. Mr. Spieker was elected chairman of the board for the year 1956–57.

The report of the business manager was approved as read. This report which accompanies these minutes, is mainly in the form of a financial statement for volume 55. Mr. Popham announced the favorable action of the executive committee of the Academy to transfer the $750 gift of Charles F. Kettering to the Journal. The money is being used to pay the increased cost of printing the Journal, a result of a new contract negotiated with the printers at higher rates. It is anticipated that the Journal will need a similar sum of money to supplement its ordinary income during 1957 if it is to print the same number of pages as in 1956 and if it is to prevent the stock-piling of manuscripts worthy of publication.

The report of the editor, Mr. Bohning, was approved as read. A copy of this report is appended to these minutes. The editor indicated that the Journal is only 5 months behind in the publication of papers. The editor feels that this period is a minimum practicable working time.

Mr. Fisk presented the report of the book review editor which was approved as read. He indicated that there is at present no back log of book reviews and he is therefore in a position to submit reviews of current books for publication. Mr. Fisk called to the board's attention the fact that any Academy member who wishes to review a book may contact him. If the book is suitable for review in the Journal, the book will be requested from the publisher and mailed to the reviewer. It is, of course, customary for the reviewer to retain the book for his library after submitting the review for publication.

Mr. Spieker was instructed to appoint a committee to audit the books of the business manager.

Mr. Bohning, who was first elected editor of the Journal on April 8, 1953, asked to be relieved of his duties as soon as a suitable successor could be found. The board accepted Mr. Bohning's resignation with regret. and expressed its thanks for the unusually competent manner in which Mr. Bohning has handled the duties of editor.

Mr. Popham nominated Mr. Henry Leroy Plaine for election as editor with the proviso that Mr. Bohning should serve as editor until a mutually agreeable time for changing the editorship can be decided upon by Mr. Bohning and Mr. Plaine.

The board elected Mr. Popham business manager and Mr. Fisk book review editor for the year 1956–57. It was suggested by Mr. Fisk, and mutually agreed by other members of the board, that Mr. Plaine should have the opportunity to choose a book review editor at the time of the next board meeting.

The board eliminated the position of associate editor of the Journal.

The secretary was instructed to include in these minutes the results of a mail balloting conducted in October, 1955. At that time the board unanimously approved a proposal to increase the subscription rate of the Ohio Journal of Science from $4.00 to $6.00 per volume (U.S.A.) and from $4.50 to $6.50 per volume (outside the United States). The new rates were to become effective as soon as practicable. The business manager announced that the higher rates will become effective with subscriptions to volume 57.

All actions of the board were approved unanimously.

Respectfully submitted,

RICHARD A. POPHAM.
Secretary of the Board

THE OHIO JOURNAL OF SCIENCE

Volume 55—Fiscal Year 1955

BALANCE SHEET

(With comparison to previous Two Years)

	Volume 53 Fiscal Year Jan. 1, 1953 Dec. 31, 1953	Volume 54 Fiscal Year Jan. 1, 1954 Dec. 31, 1954	Volume 55 Fiscal Year Jan. 1, 1955 Dec. 31, 1955
RECEIPTS:			
Bank balance at beginning of period	$1,566.51	$1,928.65	$2,417.68
O. S. U.—paid for subscriptions	2,500.00	2,500.00	2,500.00
O. A. S.—paid for subscriptions	2,069.50	2,035.50	1,944.00
Non-members—paid for subscriptions	432.50	354.50	289.39
Separate numbers, volumes and reprints sold	657.15	393.85	230.88
50 year index sold	555.00	197.50	25.00
O. A. S.—paid ½ cost of plates	237.84	312.43	303.06
O. A. S.—paid for annual report	136.28	82.04	118.18
Miscellaneous	34.94	597.57	999.13
Advertisements	387.00	280.68	282.69
Charles F. Kettering—Gift	0.00	500.00	750.00
	$8,576.72	$9,182.72	$9,860.01
EXPENDITURES:			
Spahr and Glenn—printing O. J. S.	$4,843.80	$5,119.80	$5,012.98
Bucher Engraving—plates	624.86	606.13	516.93
Postage and express	281.50	237.73	224.47
Secretary and labor	125.06	91.08	74.25
Office expenses and bank charges	61.86	85.73	20.65
Advertising of the O. J. S.	213.89	0.00	0.00
Reprints	236.89	24.00	11.25
Mailing envelopes	225.77	0.00	251.46
Refunds	0.00	3.00	0.00
Miscellaneous	34.44	597.57	1,032.91
Bank balance at end of period	1,928.65	2,417.68	2,715.11
	$8,576.72	$9,182.72	$9,860.01
Cost of supplying one volume of six numbers	$3.085	$3.046	$2.976
Subscription price to Academy Members	$1.50	$1.50	$1.50
Approximate number of Academy Members	1,250	1,200	1,200

THE OHIO JOURNAL OF SCIENCE

REPORT OF THE EDITOR OF VOLUME 55, 1955,
to the Joint Administrative Board
April 14, 1956

Volume 55 of the Ohio Journal of Science contained 408 pages of which 365 pages were devoted to 53 scientific papers in 6 fields of science (as designated by sections of The Ohio Academy of Science) and 43 pages to announcements, book notices, advertising, and index.

Respectfully submitted,

R. H. BOHNING, *Editor*

REPORT OF THE BOOK REVIEW EDITOR

The number of books received for review in 1955 was 87; in 1954 it was 74; and in 1953 it was 64. This increase in books submitted for review has not been reflected in the number of reviews published which has dropped from 53 in 1953, to 51 in 1954, and 46 in 1955.

It may also be pointed out that the number of books reviewed in the same year in which they are published is fortunately on the increase. The actual numbers are: 1 in 1953, 7 in 1954 and 13 in 1955.

In 1955, 43 books were given to the Ohio State University library.

Respectfully submitted,

FRANK W. FISK, *Book Review Editor*

REPORT OF THE JUNIOR DIVISION OF THE OHIO ACADEMY OF SCIENCE

This report closed the eighth year of activities of the Science Day program on the State level. A total of 2673 High School students participated in the seven District Science Days, and of these approximately 425 registered for the State Science Day at Wittenberg College on April 20, 1956.

Two copies of the Newsletter have been published so far this year with a third issue to be published directly following the Wittenberg meeting. This Newsletter has been sent to all Science Teachers throughout the state, as well as to members of the Senior Academy.

The Kroger Co. has very graciously presented an award and stipend to seven high schools during the year for outstanding participation of their students in science and in our program.

This year, for the first time, the Owens-Illinois Glass Co. has presented suitably marked glasses to each entrant at the State Science Day. It is hoped that still other industrial concerns can be interested in this type of program.

For the most part, the Senior Academy members have co-operated very nicely in providing judges for the various Science Days. The various sectional chairmen and vice-chairmen are to be commended for the fine help they have given.

Respectfully submitted,

ROBERT E. MCKAY
Executive Secretary
Junior Division

REPORT ON THE OHIO BIOLOGICAL SURVEY

The Ohio Biological Survey, affiliated with the Ohio Academy of Science, held an administrative board meeting on April 19, 1956. Acting Director D. M. DeLong introduced Dr. Charles A. Dambach, newly appointed Director of the Institute of Natural Resources, who outlined the possible relationships of the Ohio Biological Survey with the Institute of Natural Resources. A committee consisting of W. F. Hahnert, chairman, W. C. Beaver, H. R. Eggleston, and G. T. Jones was appointed to study the matter and to submit a report to all members of the administrative board at some future time for action.

THE OHIO FLORA COMMITTEE

The past year has been one of continued progress on the monumental task of preparing an "Ohio Flora". The endless hours of field, herbarium, and desk work which have been spent during the past year cannot easily be reported here. Among the more obvious evidences of progress are the following.

1. A preliminary list of Ohio Pteridophytes, by Wm. Adams, was distributed in June 1955.
2. A preliminary list of Ohio Legumes, by Wm. Gambill, was distributed in July 1955.
3. The manuscript, by E. J. Palmer, on the *Crataegus* of Ohio is now in the hands of the committee.
4. A manuscript by E. Lucy Braun on the Woody Plants of Ohio is well along.
5. Several thousand specimens have been added to Ohio herbaria during the past year. These represent many new county records.
6. An application for financial aid is now pending with the National Science Foundation.

Respectfully submitted,

J. ARTHUR HERRICK, *Secretary*

REPORT OF THE COMMITTEE ON THE TRAINING AND CERTIFICATION OF SCIENCE TEACHERS

This committee has been formed in response to the request of the council dated December 3, 1955. There was a brief meeting of the committee on April 19, 1956, at Wittenberg College. The following members were present: Eugene Van Cleef, J. F. Corwin, John C. Fullerton, Eleanor Longbrake, J. W. McGrath, Lincoln Petit, Walter P. Porter, and Harry A. Cunningham. Dr. John R. Mayor, director of the Science Teaching Improvement Program of the American Association of the Advancement of Science, met with the committee.

Some progress was made in defining the problems before the committee. It was decided that the committee would try to have at least four meetings during the coming year, looking toward the formulation of a report to be presented to the annual meeting of the council of the Ohio Academy of Science in 1957.

Respectively submitted,

HARRY A. CUNNINGHAM, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

Be it resolved that the members of the Ohio Academy of Science express to the administration of Wittenberg College, and to chairman Dr. W. C. Beaver of the local committee on arrangements, and to the several members of that committee, their appreciation for the excellent facilities and very thoughtful hospitality, which have contributed greatly to the success of this 65th annual meeting of the Academy.

Respectfully submitted,

WALTER C. KRAATZ
W. H. SHIDELER

REPORT OF THE NECROLOGY COMMITTEE
for the Period of April, 1955 to April, 1956

During this interval ten members of the Academy have died. The necrology report for 1954 contained a record of five deaths and the 1955 report recorded seven and now for 1956 the record rises to ten. Study of the age brackets of these deceased members shows there were three octo-genarians, two in the seventy year age group, three in the sixties, and two in

the thirty year age group. This distribution shows a slight tendency towards increase in the younger age groups. Many of the Academy members have reached their sixtieth year, so it is to be expected that the majority of deaths would occur in the upper age brackets, but of the ten deaths two were only in the thirty year group. Of these one was due to cancer and one to heart disease. This points up the frequently noted trend for these two major causes of death in the American scene, that they attack younger persons. It would be interesting to know whether the one fatality due to cardiac failure aged thirty-four was due to childhood rheumatic fever and whether the one death due to carcinoma of the lungs, aged thirty, had a history of excessive smoking. The death of the older members due to arteriosclerosis and cardio-vascular diseases is normal for that age group in the process of aging.

Respectfully submitted,

H. H. M. Bowman, *Chairman*, Toledo University
Paul Rothmund, Ohio State University
Joseph T. Maddox, Euclid, Ohio

Lawrence Russell Brunstetter

Geologist and employee of the Division of Water, Department of Natural Resources of the State of Ohio. Member of the Conservation Section of the Academy.

Mr. Brunstetter was born at Orangeville, Pennsylvania, on July 3, 1921, and secured his collegiate education at Ohio State University from which he received the Bachelor of Science degree with the major in geology. For a period after attaining his degree he was employed in the geological department of the Stanolind Oil Company at Houston, Texas. Mr. Brunstetter was unmarried and lived with his parents in Columbus, Ohio, at the time of his death which occurred on July 11, 1955, of cardiac failure, possibly due to early rheumatic fever in childhood. His untimely death at the age of thirty-four cut short a career in conservation which had all the prospects of success. He was buried in Greenlawn Cemetery at Columbus, Ohio.

Dr. Clarence Lorenzo Dow

Geographer. Professor and Head of the Department of Geography at Ohio University for many years. Fellow of the Geography Section of the Academy.

Dr. Dow was born on July 26, 1895, at Cattaraugus, New York, and attended college in 1915 and 1916 at Kansas State Teachers College. Later he completed his work for the A.B. degree at the University of Nebraska and received it in 1927. He held several high school positions in Ottawa and Cloud Counties in Kansas and at Fremont and Lincoln, Nebraska. For five years he was instructor in geology and geography at Nebraska Wesleyan College. In 1930 he received the M.A. degree from the University of Nebraska and in 1933 the Ph.D. degree. The next three years he taught geography at Clarion State Teachers College in Pennsylvania and in 1936 joined the faculty of Ohio University at Athens, Ohio, as associate professor of geology and geography. In 1941 he was promoted to the rank of professor and made chairman of his Department in 1949.

In 1919 Dr. Dow had married Cita Mae Thompson and after her death in 1936 he married Caroline Walters on August 14, 1940. By the first marriage he had a daughter, Jean Dow (Mrs. Richard Dolan) and by the second marriage a son, James Lorenzo Dow.

In addition to his regular duties at Ohio University, Dr. Dow was active in Conservation and Aviation affairs of the State and Federal Government. He taught Meterology at the Civil Aeronautics Ground School during the World War II and was himself a pilot, an officer in the Civil Air patrol. He was instrumental in 1948 in securing the Athens State Forest as a conservation project in Ohio and helped draft the legislation creating the Ohio Department of Natural Resources. He was a director of the Ohio Conservation Laboratory, also. He was the author of many articles in geographical and geological journals. In August, 1954, Dr. Dow was awarded a U. S. Educational Grant for lectures and research, and went abroad as a Fulbright Lecturer on Geography in Japan. After completing a year of visiting and lecturing in forty-two of the forty-six prefectures of Japan, he was returning to the United States when he was stricken with a coronary occlusion and died on shipboard 150 miles off the Pacific Coast on July 28, 1955. His body was brought to Athens and interred in Alexander Cemetery. Dr. Dow was a member of the Association of American Geographers, the National Council of Geography Teachers, the Ohio State Geological Survey and since 1949 a member of the Ohio Natural Resources Commission. He was elected a Fellow of the Ohio Academy of Science in 1950 and at the age of sixty, Dr. Dow's life expectancy should have seen fruition in several more years of valuable work in geography and conservation.

Dan Lee Kirlin, M.Sc.

Instructor in Zoology, Ohio State University. Member of the Ohio Academy of Science from 1950 to 1956.

Mr. Dan Lee Kirlin was born August 31, 1926, at Wolcottville, Indiana, and after completing his elementary education entered Ohio State University and was graduated in March, 1950, with the Bachelor of Arts degree, taking his major in Zoology. In June, 1952, he was

awarded the Master of Science degree. He was interested in the genetics of the mink. On June 23, 1944, he married Miss Prisilla Gregg and to this union were born two children, David L. Kirlin and John A. Kirlin. Mr. Kirlin was elected to membership in the Zoology Section of the Ohio Academy of Science and was active in his pursuit of studies in his field of Zoology and the Seminar of which he was a member. On April 18, 1956, after a brief illness, he succumbed to pulmonary carcinoma and was buried in Woodlawn Cemetery, Lima, Ohio.

Dr. Zeno Payne Metcalf

Entomologist, Professor of Zoology and Entomology at State College of North Carolina and Dean of its Graduate School. Fellow of the Section of Zoology of the Academy.

Dr. Metcalf was born at Lakeville, Ohio, on May 1, 1885, and received his Bachelor of Arts degree from Ohio State University in 1907 and the Doctor of Science degree from Harvard University in 1925. On October 20, 1909, he married Miss Mary Louella Correll and to this union was born one child, Katherine (Mrs. Micou F. Browne). In 1907 and 1908 he was an instructor in Michigan State University and from 1908 to 1912 taught as instructor at North Carolina State University. In 1916 to 1918 he was instructor in biology at Ohio State University. In 1920 he taught in the summer sessions of Michigan University and in 1925 and 1936 at Duke University. He continued his work as Associate Professor at North Carolina State to 1912. In that year he became Director of the State Experiment Station and from 1940 to 1943 served as Director of Graduate Study and from 1943 to 1950 was Dean of the Graduate School. From 1950 to 1956 he was Professor of Zoology and Entomology. In 1955 he was presented with the Oliver Max Gardner Award as the faculty member of North Carolina University who has made the greatest contribution to the human race. Dr. Metcalf was the author of nine books and a member of thirty-six learned societies. He was a key speaker at the International Congress of Zoologists in Paris in 1948 and the Congress of Entomologists that met in Sockholm the same year. He was elected president of three major biological societies—The American Entomological Society, the American Ecological Society and the American Microscopical Society. He also served on the editorial boards of four national professional Journals and has published ninety-six professional articles. He is recognized as the world authority on the Homoptera and for forty years worked on this class of insects. At the time of his death, he was working on the 42 volume series of the Homoptera of the world. Fifteen volumes are already in press and several volumes are ready for the press. The editors will attempt to publish the rest of this life work. Up to noon of the last day of his life, he was in his office working on the great catalog of the 30,000 described species of Homoptera which now contain 512,000 references. While sitting talking with his wife and daughter, he suddenly and unexpectedly died of a coronary attack on January 5, 1956 and was buried in Oakwood Cemetery, Raleigh, North Carolina.

In addition to his monumental work on the Homoptera Dr. Metcalf wrote a number of reference and textbooks, viz. *Insect Pests in Rural Life, Key to Insects, The Family Fulgoridae, General Zoology, Economic Zoology, Introduction to Zoology*, and many special monographs on genera of insects. Dr. Metcalf was a member of the Presbyterian Church and of the Society of Sigma Xi, Alpha Gamma Rho, Alpha Zeta, and Phi Kappa Phi.

Dr. Charles Bradfield Morrey

Bacteriologist Professor and Chairman of the Department of Bacteriology at Ohio State University from 1903 to 1935. Charter member of the Academy and Fellow of the Medical Section.

Professor Morrey was born on November 5, 1869, at Chester Hill, Morgan County, Ohio, and received his Bachelor of Arts degree from Ohio State University in 1890, and the M.D. degree from Starling Medical College in 1896 at Columbus. He did graduate study at the Pasteur Institute in Paris and at the University of Vienna in 1898 and 1899. In the years 1890–1891 he served as instructor in Latin, Greek, and Physiology at Ohio State University and from 1896 to 1897 was the Lecturer in Physiology and Histology at Starling Medical College. In 1899 he became Assistant Professor of Anatomy, Physiology, and Bacteriology at Ohio State University, and in 1903 he established the Department of Bacteriology in the State University as Chairman of the department and which position he retained until he became emeritus in 1935.

On October 24, 1898, he married Miss Grace Hamilton Jones and to this union there accrued three children, viz. Professor Charles B. Morrey Jr.; Marion (Mrs. Otto C. Richter); Jessie (Mrs. Michael V. Condoide).

Professor Morrey received many honors and was the author of several texts in his field, *Fundamentals of Bacteriology*, 1929, and *Laboratory Exercises in Bacteriology*, and numerous papers, as "Vaccination in Colds".

He was a charter member of the Ohio Academy of Science, and a Fellow, Member of the American Bacteriological Society, the American Chemical Society, the Sigma Xi (President, O.S.U. chapter, 1919), A.A.A.S., the Faculty Club of the University, the Canadian Club and the University Club.

On April 24, 1955, Dr. Morrey passed away at his home, death being due to complications

of arteriosclerosis, hypertension, and cardiac failure. He was buried at Union Cemetery, Columbus, Ohio, rich in accomplishment and honor.

Dr. Raymond C. Osborn

Zoologist and Entomologist. Professor of Zoology and Entomology at Ohio State and Department Chairman from 1917 to 1942. Fellow of the Zoology Section of the Academy.

Dr. Osborn was born at Newark, Ohio, on January 4, 1872, and after securing his elementary education in Ohio public schools entered Ohio State University and received the Bachelor of Science degree in 1898. In 1900 he received the M.Sc. degree and in 1949 was awarded an Honorary Doctor of Science from Ohio State University. In 1906 he received the Ph.D. after several years graduate work at Columbia University as a teaching Fellow. For the next four years he held a position as instructor and later Assistant Professor at Barnard College, New York City, and Professor of Biology at Connecticut College for Women. In 1910 he became the Associate Director of the New York City Aquarium where he served until 1915 when he became an instructor in Starling Medical College, Columbus, Ohio, after a short period as Professor of Biology at Fargo College. In 1917 he was made head of the Department of Zoology and Entomology at Ohio State University, where he remained until he became emeritus in 1942.

On August 19, 1903, Dr. Osborn married Miss Mary Hubbell who survives him in Columbus.

From 1945 to 1952 he was a Research Associate of the Allan Hancock Foundation at the University of Southern California. In 1950 he was awarded the Elliot Gold Medal by the National Academy of Science for his contributions in the field of zoology. Dr. Osborn was an honorary member of the American Museum of Natural History, a life member of the Outdoor Writers Association, a Fellow of the AAAS and the Ohio Academy of Science, a member of the Sigma Xi Society, American Society of Naturalists, American Society of Zoologists, American Fisheries Society, American Society of Economic Entomologists, Ecological Society of America, the American Society of Parasitologists, American Microscopical Society, American Society of Limnology and Oceanography, of which he was vice-president in 1938 and president in 1941, and the New York Academy of Science.

On August 6, 1955, Dr. Osborn passed away at his home in Columbus of arteriosclerosis and was buried in Cedar Hill Cemetary, Newark, Ohio. He was active in many local organizations in Columbus and after a long and busy life adorned with lasting friendship of thousands of students and colleagues he left a wide gap in the scientific circles of Ohio.

Dr. Roderick Peattie

Geographer. Professor of Geography at Ohio State University and Fellow of the Geography Section of the Academy.

Professor Peattie was born in Omaha, Nebraska, on August 1, 1891. He received his Batchelor of Science degree from the University of Chicago in 1914 and the Ph.D. degree from Harvard University in 1920. On June 11, 1917, he married Margaret Rhodes by whom he had three children, Roderick E., Anne, and Michael R. Peattie. After her decease in 1945 Dr. Peattie married Miss Ruth Cavett in October, 1947.

He was a specialist in physiography and from 1916 to 1919 served as an assistant in that work at Chicago University during the summer. In 1915 he was an assistant at Radcliffe College in the same work. From 1916 through 1917 he was an Austin Teaching Fellow at Harvard and also made some topographic surveys for the U. S. Geological Survey. During 1919 and 1920 he was employed as field geologist for the Cosden Oil and Gas Company, and at the same time served as Assistant Professor of Geology at Williams College. In 1920 he joined the faculty of Ohio State University as Associate Professor of Geography and in 1925 was raised to the rank of Professor in which office he remained until his demise. During 1944 and 1945 Dr. Peattie was on leave of absence serving as Chief of the War Information Office for the Union of South Africa. In several summers between 1921 and 1938 he was summer lecturer in geography at the University of California, Clark University, Northwestern University and the University of Wisconsin. In 1918 he had been an instructor in the Army Engineers School of the A.E.F.

Dr. Peattie was a member of the Association of American Geographers, Fellow of the Ohio Academy of Science, Sigma Xi and Alpha Delta Phi. He was the author of *The Geography of Ohio* in 1924 and two textbooks, *College Geography* and *Mountain Geography*, special monographs such as *Exploring Geography*, *Geography in Human Destiny*, *The Incurable Romantic*, *How to Read Military Maps*, *Look to the Frontiers*, *Struggle on the Veld*, and for a number of years was Editor of the American Mountain Series. In August, 1955, Dr. Peattie suddenly died of cardiac failure, and his remains were cremated and the ashes returned to this earth which had most of his life impelled him to its study.

Dr. John Ernest Potzger

Botanist, Chairman of the Department of Botany of Butler University, 1952 to his death in 1955. Member of the Plant Science Section of the Academy.

Professor Potzger was born in Presque Isle County, Michigan, on July 31, 1886, but most of his life was spent in Indiana. He received his Bachelor of Arts degree and the Master of Arts degree from Butler University in Indianapolis, and the Ph.D. degree from Indiana University in 1932. He was invited to his alma mater at Butler to become Professor of Botany in 1931 and was made head of the Department in 1952. From 1947 to 1951 Dr. Potzger was a Lecturer at Purdue University's Summer Conservation Camp. From 1952 to 1955 he was

the guest Research Director of the Service de Biogéographie of the Université Montreal at its Biological Station at Lac Monroe in the Province of Quebec.

On June 9, 1947, he married Dr. Margaret Esther Whitney. Dr. Potzger was a member of Phi Kappa Phi, Sigma Xi, elected to the Indiana Academy of Science in 1926, he became a Fellow in 1932. He was also a member of the Wisconsin Academy and the A.A.A.S. As an active member of the Central Association of Science and Mathematics Teachers, he was editor of its Journal and Yearbook from 1940 to 1945. He was elected vice-president of the Association in 1947 and president in 1948. He was also closely identified with the Ecological Society of America and served as its president in 1954–1955. In 1949 he was granted the J. I. Holcomb award for having made the greatest contribution to education in Butler University. On September 18, 1955, Dr. Potzger died of coronary occlusion and his remains laid in Concordia Cemetery in Indianapolis.

Dr. Waldo Eduard Steidtmann

Botanist and Chairman of the Department of Biology at Bowling Green State University, and Fellow of the Plant Science Section of the Academy.

Professor Steidtmann was born on April 27, 1896, at Prairie du Lac, Wisconsin. He received his A.B. degree from the University of Wisconsin in 1923 and the M.A. degree from the University of Michigan in 1929, and attained the Ph.D. from the same University in 1935. From 1923 to 1932 he served as instructor at Marquette University in Milwaukee. From 1932 to 1935 he was an instructor at the University of Michigan and in 1936 was appointed Assistant Professor of Biology at Bowling Green University. In 1940 he was raised to the rank of Associate and in 1947 advanced to the rank of Professor of Biology and made Chairman of the Department and so remained until his death.

On September 8, 1930, Dr. Steidtmann married Miss Evelyn Dressel and to this union were born two children, Sally Ann Steidtmann and James Richard Steidtmann.

Professor Steidtmann was elected Professor of the Year at Honors Day in May, 1955, by Omicron Delta Kappa, national Leadership Fraternity. He was also a member of Phi Sigma, Beta Beta Beta, Sigma Xi, Omicron Delta Kappa, the Botanical Society of America, A.A.A.S., Michigan Academy of Science, Alpha Tau Omega fraternity, and many other civic and social organizations, as well as the Presybterian Church which he served as an elder, trustee and chorister. On June 21, Dr. Steidtmann suddenly died of coronary occlusion and was buried in Oak Grove Cemetery, Bowling Green, Ohio.

Dr. Frederick Clayton Waite

Professor of Histology and Embryology at the College of Medicine, Western Reserve University, from 1904–1940. Member and Fellow of the Medical Science Section.

Professor Waite was born at Hudson, Ohio, on May 24, 1870. His secondary education was secured in Western Reserve Academy at Hudson from which he was graduated in 1888. He then entered Western Reserve University at Cleveland and was graduated with the Bachelor of Letters in 1892. He received the Master of Arts degree in 1893 and the Ph.D. from Harvard University in 1896. In 1943 he was awarded the Honorary Degree of Doctor of Humanities by Western Reserve.

On December 24, 1916, Dr. Waite married Mrs. Emily Bacon Fisher of Cleveland. In 1892 he had been appointed Assistant Professor of Biology at Western Reserve and remained until 1895 when he received the Morgan Fellowship at Harvard in 1896 and remained until 1898 a student in zoology. In 1897 he was an instructor in a high school in New York City, and from 1898 to 1900 was a professor in New York University. In 1900 to 1904 he was an assistant Professor of Anatomy at Rush Medical College in Chicago. In 1904 he went to his alma mater, Western Reserve, as Assistant Professor of Histology and Embryology and served as Associate Professor from 1904 to 1906 when he became Professor and continued until 1940 when he became emeritus. From 1907 to 1917 Dr. Waite was Secretary of the Faculty of Medicine. During 1917 and 1918 he served his country as a Captain in the Sanitary Corps of the U. S. Army and returned as a Major in the Reserve Corps in 1919.

He was a Fellow of the A.A.A.S. and of the Ohio Academy of Science, of which he was President in 1930.

He was a member of the American Society of Anatomists, American Society of Naturalists, the American Zoological Society, and the American Society of Microscopists, the Cleveland Academy of Medicine, and an honorary member of the Cleveland Dental Association, the Vermont Historical Society, the New England Society of the Western Reserve (President in 1932), the American Association of the History of Medicine, the Sons of the American Revolution, and Sons of Colonial Wars, Sigma Xi, Phi Beta Kappa, Alpha Omega Alpha. He also served as Vice President of the Association of American Medical Colleges from 1905 to 1906, and was a Fellow of the American Medical Association and a member of the University Club and the Rowfant Club of Cleveland. He was the author of the *Hitory of the Western Reserven School of Dentistry* and a *History of Western Reserve University*, and sa book entitled *The Hudso Era* about his native community. He also wrote the *Story of Western Reserve Medical College* and the *History of the New England Female Medical College.*

His busy and fruitful life closed on March 30, 1956, due to cardiovascular conditions induced by his advanced age of 86. He was buried in Pine Hill Cemetery, Dover, New Hampshire, where he had lived with his wife since 1940 when he retired as emeritus professor.

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